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METEOROLOGY

MODEL OF CLIMATE AND GLOBAL ECOLOGY

Moscow PRIRODA in Russian No 9, Sep 81 pp 68-77

[Article by Vladimir Valentinovich Aleksandrov, candidate of physical and mathematical sciences, Computation Center USSR Academy of Sciences, and Nikita Nikolayevich Moiseyev, corresponding member USSR Academy of Sciences, deputy director, Computation Center, USSR Academy of Sciences]

[Text] The problem of a profound study of the processes determining the properties of the environment and modifying it is evidently the main task of mankind in the immediate future. Despite a tremendous increase in scientific and technical potential, mankind, however paradoxical this may be, is becoming more and more dependent on the quality of the environment. The social structures created by people, as well as their economy, were always sensitive even to extremely slight changes in properties of the habitat. It is scarcely necessary to discuss the widely known facts showing that the maintenance of man's modern living standards is possible only in a very narrow range of change in environmental parameters: temperature, precipitation, wind intensity, pressure fluctuations, humidity, etc. Scientific and technical progress and the increase in the earth's population associated with this have made this dependence dramatic in many respects.

Some History

The peculiarities of the ecological situation into which mankind is gradually being drawn began to attract the attention of the broad scientific community at the end of the 1960's. In the popularization of these problems a major role was played by the so-called Rome Club, a group of businessmen, jurists and scientists brought together by common interest in the prospects for development and consequences of the scientific and technical revolution, the problems generated by the uncontrolled growth of population and the constant decrease in the natural resources of the planet.

One of the most important actions of the Rome Club was the development of a general approach to a multisided solution of this group of problems, that is, in essence, the development of a program for investigations of global ecological processes. To a considerable degree this program was also realized in the studies of the Rome Club. The beginning of these investigations was laid by a well-known study by Professor G. Forrester, entitled "World Dynamics"¹. This was followed by a whole

series of publications. The most famed of these was that published by a group of specialists under the direction of D. Meadows². Published in enormous printings in many languages under the general name LIMITS TO GROWTH, it transformed the problem of global ecology into one of the most popular scientific problems.

The work of Meadows was followed by a more detailed investigation which was directed by M. Messarovich and E. Pestel' and a number of other studies.

The most important among the studies carried out under the aegis of the Rome Club was without question and in the real sense of the word the pioneering study by Forrester. He developed a method for the formalized description of complex processes which was given the name "system dynamics method." This method exerted a strong influence on most subsequent investigations. Applying this method, Forrester for the first time gave quantitative estimates of the possible values of the principal characteristics of the world ecological process. These estimates, although conditional, demonstrated the fundamental possibility of a changeover of the discussion of the future of industrial development from the sphere of general considerations to the channel of scientific analysis.

The work of Forrester contained conclusions of a fundamental character. He demonstrated for the first time that the uncontrollable development of electric power, industry, growth of population and with the retention of modern trends of wasteful use of natural resources inevitably will disrupt the equilibrium of the processes determining the interaction between man and his environment necessary for the existence of civilization.

Subsequent investigations carried out in the West, in Japan, Argentina and other countries relied in essence to the Forrester methods. They did not contain any new concepts and for the most part were devoted to a refinement and development of his approach.

From our point of view the importance of the studies of the Rome Club is that they raised the problem and focused the attention of a wide circle of investigators on it.

During recent years it has become understandable that the possibilities of the schemes used by Forrester were rather limited and that now to a considerable degree they have been exhausted. Today we are at the very beginning of a new stage which requires systematic investigations of a fundamental character.

Investigations of the global ecological process were also initiated in the early 1970's in the Soviet Union (at the Computation Center, USSR Academy of Sciences, at the Institute of Biomedical Problems, at the Institute of Radio Engineering and Electronics, USSR Academy of Sciences, at Moscow State University imeni M. V. Lomonosov). However, the nature of these investigations and their purposes were completely different.

Biospheric Approach

The center of gravity of investigations of the "Forrester" type fell in the sphere of economics. Using the simplest relationships between production and consumption, relating them (to a high degree arbitrarily) with demographic processes and taking

into account the modern trends in the development of these processes, the authors were able to obtain extremely graphic forecasts of the course of the world economic process.

We felt that such an approach was inadequate.

The problem of investigating the global ecological process is far more complex. It involves a forecast on the basis of an analysis of the demographic situation and modern trends in development of the economy. We feel that the point of departure should be a recognition of the necessity for a profound study of the interrelationship between human civilization and the dynamic processes transpiring in the environment.

Accordingly, first of all it is necessary to investigate the general laws of development of the biosphere, one of whose components is mankind. We must learn how to determine the admissible loads on the biosphere, without disruption of those conditions of the quasistatic state in which it presently exists.

In using the term "biosphere" we have in mind that thin envelope of the ocean, atmosphere and land in which life exists.

It is now generally recognized that human activity will lead to a global change in the environment in which we live. Unfortunately, these changes usually have a negative character and in a number of cases are irreversible. Numerous publications usually of a popular or general methodological character now are being devoted to this theme. Articles have recently appeared which discuss programs for scientific research. Their serious discussion is all the more necessary now that in essence a new direction is being formed which could arbitrarily be called the dynamics of the noosphere.

The creation of a research program which would be capable of bringing together the efforts of specialists in different directions is not only the first stage in the work, but is also an independent scientific problem. We note that a scientific quest has begun, serious results of which can be expected only after several decades. Therefore, we have devoted special attention to the creation of a foundation for such investigations.

We felt that the central point in this program should be the creation of a mathematical approach by means of which it would be possible to combine different investigations of the principal characteristics of the global ecological process into a general scheme and to evaluate the influence of human activity on the properties of the environment. As time passes the anthropogenic load on the biosphere will only intensify and therefore the role of the approach for analysis and prediction of the consequences of the increasing anthropogenic effects is enormously increasing. It can be hoped that such an approach will one day become a tool for the analysis of different alternatives for the development of mankind.

It seemed to us that this preliminary stage, which we will call the formulation of the program, should require considerable time, possibly about ten years. However, even today it is possible to cite some results and speak of the completion of a number of preliminary investigations both in the field of methodology and in the development of the principles of instrumentation, which is a prerequisite for the

development of further work.

The approach to which we make reference is based on a system of models reflecting (describing) the principal features of dynamic processes in the atmosphere.

It is now obvious that for the most complete description of the environment only a numerical model is suitable, to be more precise, a system consisting of several large numerical models.

We will tell of an approach to the formulation of such models which is being developed at the Computation Center, USSR Academy of Sciences.

The system of numerical models, the approach which has now been proposed at the Computation Center, USSR Academy of Sciences, has as its objective a description of the anthropogenic changes in the principal characteristics of global processes transpiring in the biosphere. From this point of view, for solution of the principal problems in global ecology the biosphere can be described using three interacting models: the cycling of matter in nature, human activity and climate.

We note here that the most vulnerable component of the environment most likely is specifically climate. There are more than a few arguments to support such an assertion. First of all, even "insignificant" variations in mean temperatures in the range $2-3^{\circ}$ in any direction will already lead to such changes in living conditions under which the adaptation of mankind will be very difficult. Equally dangerous are local changes in the hydrological cycle of the atmosphere which can, for example, bring about the broadening of arid zones. Simple estimates show that anthropogenic influences even in the coming century can be capable of warping climatic characteristics from the admissible range of their changes. An increase by only a factor of 100 in the quantity of energy now produced by the combustion of hydrocarbons and nuclear processes can lead to such a change in climatic characteristics that qualitatively there will be a restructuring of the entire biosphere. (With modern rates of development of energy such a situation is possible only after a hundred years.)

Thus, a scientific approach to investigation of the dynamics of the biosphere in actuality will require a joint study of all its principal components.

In 1975 specialists at the Computation Center, USSR Academy of Sciences, initiated systematic investigations of the cycling of matter in nature and in 1978 work was completed on the first (instructional) version of the corresponding model. This model, at its basis ecological, describes the processes transpiring in the biota³ and the cycles of carbon dioxide, nitrogen and water in biological communities.

The accuracy of this model for the time being is low. We are able to describe the processes transpiring on land very well. As a result, on the continents the grid at whose points of intersection a solution is sought for the finite-difference equations of the model, can be selected quite fine. The limiting factor here is not the structure of the model, but the expenditures of computer time, the volume of information accessible to us and the computer memory. However, the description of water ecosystems is far more complex and therefore in the first version of the model the entire ocean is regarded as a single-unique biocoenosis⁴.

The initial data for our biogeocoenotic model were selected as a result of analysis of the data available in the literature. Their choice was possible only with the broad participation of Soviet organizations and UNESCO. Work on the model of the biota led to the completion of an important stage in the investigations which makes it possible, on the one hand, to comprehend some features of the process of global circulation of matter, and on the other hand (and this is more important), the formulation of a concept considering the character of impending long-range investigations relating to the circulation of matter and energy processes. Expressed differently, we were convinced of the fundamental possibility of use of modern electronic computers for this purpose. The completed work also determined our own positions in this program, which possibly will one day be adopted.

Today the model of the biota is a system of operative programs written in APL programming language. It can be printed and used for instructional purposes.

Now work is proceeding on the improvement of an ecological model: a description of the dynamics of populations existing in nature and the nitrogen cycle is being refined and what is most important, is increasing in resolution. At the same time, work is being done on programs making it possible to use this model in a man-machine dialogue regime.

Work on the creation of a model of human activity was most difficult from the fundamental point of view. The interaction of man and the environment is determined, in particular, by productive activity. Accordingly, it is natural to assume that at the basis of human activity there should be a description of economic and demographic processes.

Traditional economics operates with balance relationships which relate the volumes of expenditures on productive processes to the volumes of goods and services produced. But for a description of man's effect on the environment it is necessary to describe the effects of his economic activity. It is necessary to know how, as a result of industrial activity and agricultural production, there is a change in the structure of the flux of carbon dioxide and aerosol into the atmosphere, how the albedo of individual regions and the structure of thermal contamination changes, etc. Problems of such a type are new for economic science; there is no information on such interactions in the economic literature.

There is still another group of factors which must be taken into account if the development of global ecological science is to be possible.

In the work of the Rome Club economics was described by very simple relationships which took into account the change in capital and the scales and character of production. As a result of such an approach the authors found the "trends" in development characterized by a sharp change in the corresponding parameters and great amplitudes of their fluctuations. Such a result can be attributed to the fact that the authors did not take into account the internal mechanisms subject to any economic system with a definite inertia. In addition, the great amplitudes of fluctuations of the "trend" in social development indicate that the appearance of extremal states of society is possible in the neighborhood of the boundary of its homeostasis. But under these conditions it is known that balance relationships are inadequate and there is no use for them: in such situations the behavior of human society should probably change radically.

Thus, the creation of a rational system of an ecological-economic model requires a profound study of the structure of the principal social mechanisms. And this is also a new direction in investigations lying at the contact between the social and the natural sciences.

Base Model of Climate

A model of climate should describe the real physicochemical regime of the biosphere. Extremely high requirements are imposed on this model. The quality of precisely this model decides the success of modeling of the biosphere as a whole.

By the definition of A. S. Monin and Yu. A. Shiskov "climate is a statistical set of states which the ocean-land-atmosphere passes through during periods of time of several decades."⁵ This definition reflects the role of the three components which make the main contribution to the state of the environment: ocean inertia, slight atmospheric instability and the land, which is the most subject to human influence.

In contrast to the biological block and the block of the model of human activity, where we began work virtually from zero, the modeling of climate over the course of a rather prolonged time was the object of the efforts of a number of researchers. Accordingly, we deemed it desirable not to create new models, but use one of the existing ones as a base model. The choice was not such a simple problem.

We require in the model of climate an acceptable computational complexity, on the basis of which conclusions could be drawn concerning the influence of climate on the economic activity of people and on the basis of which it would be possible to select such a strategy of behavior which to the greatest degree would correspond to the developing climatic conditions. For this purpose it is necessary to have at least the seasonal values of mean temperature, phytoactive radiation and precipitation. Information characterizing the deviation of these parameters from their means: the corresponding values of the anomalies, dispersions, etc., is also important.

The requirements on the model of climate include the level of resolution. The need for an analysis of regional situations and the prediction of estimates of productivity of natural and artificial coenoses makes it necessary to adopt as the maximum admissible spatial grid a grid with squares of about $5 \cdot 10^0$. In this case it is possible to discriminate the principal agricultural and industrial regions quite well.

The model should allow a real possibility for analysis of the evolution of climate in the course of several decades.

Proceeding on the basis of all these requirements and taking into account that the principal climatic model is a model of the atmosphere, we decided to select as the base model a model of global circulation of the atmosphere formulated by Mintz-Arakawa in the Gates version⁶.

This is a hydrodynamic model of the atmosphere, to be more precise, a model of the troposphere, which lies between the underlying surface and the tropopause, pressure in which is assumed to be equal to 200 mb. The difference equations for the model were written in a geographic grid with an interval of 4^0 in latitude and 5^0

in longitude. Vertically the troposphere is broken down into two layers of equal mass. The underlying surface reflects the real picture of the earth, taking into account the distribution of the continents and oceans with sea ice and the real orography of the land with its distribution of continental ice and snow cover, dependent on season. As boundary conditions there is stipulation of the position of the sun as a function of current time and temperature of the ocean surface.

Such a model describes macroscale movements of air masses arising due to the non-uniform release of energy in the near-surface layer of the atmosphere, with the earth's rotation taken into account. The energy "inputs" and "outputs" are formed within the framework of this model due to the solar radiation and phase transitions of water present in the atmosphere and at the underlying surface. The transfer of short-wave solar radiation and long-wave thermal energy emitted by the air and the underlying surface is dependent on the thermodynamic state of the atmosphere and the presence of clouds in it. The latter circumstance is an important merit of the Mintz-Arakawa model. In actuality, the transfer of moisture, accompanied by evaporation and condensation, the development and disappearance of clouds of different types and thicknesses, plays an enormous role in the mechanics and energetics of the atmosphere. Suffice it to mention that about one-third of all the solar heat absorbed by the atmosphere is expended on evaporation.

The volume of carbon dioxide and aerosol in the atmosphere and also the albedo of the underlying surface and thermal contamination in the model of global circulation are assumed to have fixed values. They are the "inputs" in the model of climate which must be developed in the other blocks of the global model.

The climatic model must include a description of the ocean. Models of global circulation of the ocean are too complex for the modeling of climate and models of the ocean with few parameters, on the other hand, provide excessively general information inadequate even for formulating the boundary-value conditions in the model of circulation of the atmosphere and for the functioning of the entire ecological model. A model of the ocean acceptable for us must produce a geographical distribution of the parameters of its surface layer and a flux of carbon dioxide through the water surface.

For a description of interaction between the ocean and atmosphere we selected the Ye. P. Borisenkov model, supplemented by a simple model of the upper layer of the ocean. The Ye. P. Borisenkov model describes well the global energy interaction between the atmosphere and ocean⁷. A model of the upper layer makes it possible to obtain necessary information for the "input" in the model of atmospheric circulation.

An ocean model must contain a dynamic description of sea ice. This problem now has several formalizations applicable for global ecological modeling.

Any experiment with such a climate model essentially involves the Cauchy problem solution: on the basis of a stipulated initial state of the atmosphere and ocean and stipulated external conditions it is possible to solve a system of equations in hydrothermodynamics as a function of time and coordinates. It is understandable

that the initial state cannot be selected arbitrarily. It must be matched with the laws of conservation of mass, momentum and energy.

By using as a point of departure some typical situation on 1 January and integrating the equations of the model for a period of time equal to 31 days, we obtain one of the possible versions of distribution of temperature, cloud cover, precipitation, etc. for the month of January. By selecting another initial situation and repeating the integration, we obtain still another possible distribution of the meteorological elements in January. By analyzing a sufficiently great number of versions corresponding to a reasonable set of initial states and by carrying out statistical processing of these records we obtain some mean pattern which it is natural to call January climate.

In exactly the same way it is possible to proceed to the remaining months. For this purpose it is sufficient to change the external conditions: the position of the earth in its orbit, mean distribution of sea ice, snow cover and distribution of temperature of the ocean surface.

At the present time it is sufficient for us to have one representative month for each quarter: January, April, July, October. Taken together, they can be called a "standard model of climate"⁸.

The difficult problem arose of the extent to which this model adequately describes real natural processes. The direct path to a solution is a statistical processing of the hydrometeorological information. Such work must be done once. This is difficult and meticulous work which requires much time and effort. However, it is possible to evaluate the quality of the model, that is, the correspondence of its conclusions to real observations, also by the use of approximate tests. January, for example, is characterized by such phenomena, first of all, as westerly transfer: the movement of air in the North Atlantic and Europe which is accomplished by means of an irregular series of cyclones moving from west to east; second, the Aleutian Low, an extensive region of low pressure in the northern part of the Pacific Ocean; third, the Siberian High, which sets in during the course of January in Central Siberia; fourth, circular movement of cyclones around Antarctica and some others. The mean climate model must reproduce these phenomena: this is the necessary condition for its applicability.

It was found that the model with great accuracy reproduces those patterns which weathermen are accustomed to observe. A more detailed analysis shows that from the point of view of a description of global ecological processes this model reflects well the state of climate undisturbed by human activity.

Model of Linear Trends

But the formulated model is still far short from what is necessary for studying the evolution of the ecological situation. We need a climatic block for a large biospheric model which would make it possible to compute those changes in mean climatic characteristics which arise as a result of anthropogenic factors. But at our disposal there is only some nominal variant corresponding to the present-day level of the anthropogenic load on the biosphere.

The next step is not trivial and it requires special discussion.

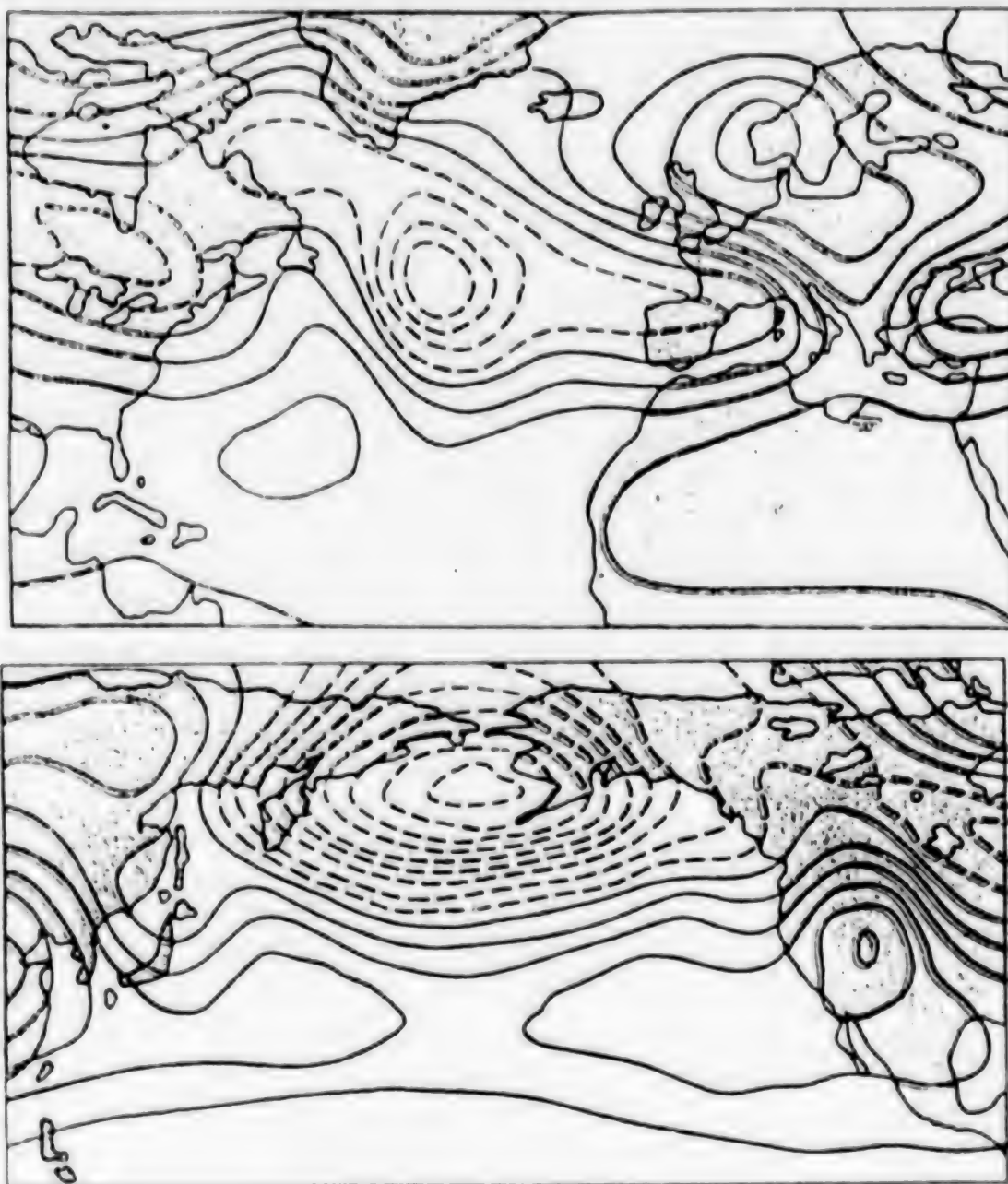


Fig. 1. Isolines of atmospheric pressure reduced to sea level in the North Atlantic region. The solid curves correspond to pressure of 1000 mb or more. The distance between isolines is 1 mb. The dashed curves correspond to a pressure of 995 mb or less. At the center of the North Atlantic there is a cyclonic formation which moves eastward. One of the January situations.

All the blocks in the biosphere model are related to the input and output parameters. This means that the biosphere model is a unified system whose dimensionality is so great that the possibility of a direct checking of the model is precluded not only on existing electronic computers, but also on computers of hypothetical capability. The carrying out of a "through" analysis of the model is unrealistic not only today but even in the future. It is therefore necessary to work out a method for the analysis of individual blocks of the model which at the same

time could serve for organizing a man-computer dialogue.



Fig. 2. Same as Fig. 1, but for the Antarctic region. It is easy to see the "track" of cyclones moving around Antarctica. All the patterns were obtained on a graphic display.

For this purpose we proposed an approach making it possible to represent the information in the form of tables (matrices) relating the variables of the output to the variables of the input.

	A	Q	[CO ₂]
T	$\partial T / \partial A$	$\partial T / \partial Q$	$\partial T / \partial [CO_2]$
S	$\partial S / \partial A$	$\partial S / \partial Q$	$\partial S / \partial [CO_2]$
P	$\partial P / \partial A$	$\partial P / \partial Q$	$\partial P / \partial [CO_2]$
.....

For the model of climate this matrix can be called the matrix of linear climatic trends⁹. The upper line gives the principal input parameters of a climatic model (albedo A, thermal contamination Q, concentration of carbon dioxide [CO₂], etc.), and the first column -- the principal output characteristics, which are the input characteristics for other blocks of the global ecological model (biota, agricultural production, etc.). These are temperature T, photoactive radiation S, precipitation P, etc. In the grid squares situated at the intersection there are values of the derivatives, computed for the base state of the initial model.

However, the type of matrix of linear climatic trends is greatly simplified. In actuality, the first column does not give the mean temperature or photoactive radiation, but the set of their values, determining both the geographical and seasonal features of the distribution of this parameter. Thus, the determination of anthropogenic trends in climate involves the computation of the principal meteorological parameters varying under the influence of variations in the base set of parameters determining the earth's climate. In turn, these variations are caused by the industrial and other activity of people in our day or in the immediate future.

Such a table of linear trends is a parameterization of climatic changes and corresponds to the requirements mentioned above.

In actuality, we will assume that a researcher imposes a definite scenario of development of productive activity. As a result of computations we will determine the quantity of energy which will be produced within the framework of the scenario, effluent of carbon dioxide in the atmosphere, change in albedo due to change in the structure of vegetation, etc. We will make these computations for any definite year which is of interest to the researcher and which naturally is not very distant from the present moment (only such conditions can guarantee the success of the evaluations).

Having at our disposition a table of linear trends, we will easily compute the climatic characteristics for any square of the geographic grid. For example, for the temperature value T^* for the year t^* we will have:

$$T^* = T_0 + (Q - Q_0) \frac{\partial T}{\partial Q} + (A - A_0) \frac{\partial T}{\partial A} + \dots$$

where Q_0 , T_0 , A_0 ... are the initial values of the nominal.

Since we are assuming a linearity of the trends, it is easy to compute the change in climatic parameters as a function of time:

$$T(t) = T_0 + \frac{T^* - T_0}{t^* - t_0} (t - t_0).$$

Having such evaluations, we can correct the earlier computed scenarios of development, etc. Thus, the scheme of linear trends affords a possibility for the decomposition of the model and the organization of rational procedures for its analysis.

Prospects and Difficulties

The "linear trends tables" method is determining our work program for the immediate future. But on the way to implementation of this program there are two fundamental problems which arise. The first is related to an enormous number of computations necessary for the "playback" of any specific scenario, and second, in actuality, generated by the first, with a colossal volume of information obtained during modeling.

One of the fundamental characteristics of the already described hydrodynamic models of climate is very great expenditures of computer time on the solution of one problem (that is, in the calculation of one variant). We need a model which can be used in a man-machine dialogue regime for selection of rational strategies, that is, a model providing for multiple repetition of simulation experiments. The expenditure of a great volume of time on one integration creates a fundamental

obstacle for the use of the climatic model. We have an acute need for an algorithm which would make it possible to compute the equations of the model a hundred times more rapidly than any of the algorithms available today.

The use of models of general circulation of the atmosphere and ocean leads to an accumulation of extensive masses of numerical data. The use of a global model of the biosphere will involve the generation of a still greater quantity of information, whose analysis is the final part of the modeling problem. We emphasize that this final stage is as important as all the preceding stages in solution of the problem.

The volume of information collected during modeling is so great that it cannot be used in unorganized form. The modeling cannot be considered complete without a representation of the results in the form of zonal and geographical distributions of the principal meteorological characteristics, fluxes of different forms of energy, etc. if there is no spectral analysis of the results necessary for the use of ecological and economic models. For these purposes it is necessary to have an extensive set of special "diagnostic" programs.

Thus, the successful development of the discipline which we will arbitrarily call the dynamics of the biosphere, in addition to a purely meaningful analysis, requires an extremely high "systemic" level of the computer processing. Despite the fact that work on the formulation of a system of models describing biospheric processes of a global character has been going on for several years, it is at the very initial stage. As we have already mentioned, it will require enormous efforts over a great many years. Moreover, we assume that with time it will inevitably expand into some special international service with continuously renewable information banks and systems of models. By this means it will be possible to study various scenarios of development which are being developed by researchers of different countries and fields of specialization.

Any discussion of work in the early stage of its development is always useful and in addressing readers with this article we had as our objective the informing of a wide circle of specialists with the most different directions in today's status of the problem.

Our article has had still another purpose. The problem which we have raised is too complex for any one group of specialists and we would be happy to see the appearance of scientific cooperation. Formal channels in such studies of an exploratory character are usually not very effective. The journal PRIRODA, from our point of view, can serve as the collective organizer which we are now lacking.

FOOTNOTES

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3. We recall that the biota is the historically developing totality of plants and animals, combined in a common habitat. As is well known, living organisms play a role of more than a little importance in the processes of global circulation of matter.
4. See the series of articles on systems analysis of dynamic processes in the biosphere: "Systems Analysis and Mathematical Models," VESTNIK AN SSSR (Herald of the USSR Academy of Sciences), No 1, 1979, p 97; Moiseyev, N. N. and Svirezhev, Yu. M., "Systems Analysis of Dynamic Processes in the Biosphere," VESTNIK AN SSSR, No 2, 1979, p 47; Moiseyev, N. N., Krapivin, V. F., Svirezhev, Yu. M. and Tarko, A. M., "An Approach for Formulating a Model of Dynamic Processes in the Biosphere," VESTNIK AN SSSR, No 10, 1979, p 88; Svirezhev, Yu. M. and Tarko, A. M., "Modeling of the Global Biogeochemical Cycle of Carbon," VESTNIK AN SSSR, No 12, 1979, p 95.
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8. The model was used only for the month of January. This variant within the framework of the so-called permanent January was employed by V. V. Aleksandrov and V. Ya. Sergin using a "Kray-1" electronic computer at the United States Atmospheric Research Center at Boulder, Colorado. This model has now been reprogrammed with use of a "Saber-172" computer and the computations are being continued at the Computation Center, USSR Academy of Sciences, Leningrad, and at the USSR Hydrometeorological Center, which has these computers.
9. The word "trend" [uncommon in Russian] means "direction" or "tendency."

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CSO: 8144/0163

POTENTIAL CHANGE IN CLIMATE BY YEAR 2000

Moscow BROSHYURY IZDATEL'STVA "ZNANIYE": NOVOYE V ZHIZNI, NAUKE, TEKHNIKE, SERIYA "NAUKA O ZEMLE": GEOGRAFICHESKAYA LETOPIS' KLIMATA in Russian No 8, Aug 81
pp 32-34

[Excerpts of article by O. A. Drozdov, doctor of geographical sciences]

[Excerpts] The climatic instability of recent decades, accompanied by some phenomena which had not been observed earlier, with manifestation of interest in aspects of climate observed in the past but which have not been reflected in former studies, has given rise to a number of hypotheses concerning possible characteristics of the climatic background for the onset of the coming century. According to these hypotheses, the climate is expected to be considerably colder than that of today, or considerably warmer, and in both cases drier. We will attempt to analyze the basis for each type of hypothesis.

The course of temperature during the last century was characterized by its growth up to the late 1930's (in some months and in individual regions up to the 1950's), followed by onset of a temperature decrease. This course was interrupted several times by shorter intrasecular fluctuations associated with more frequent explosive eruptions of volcanoes (early 1900's, mid-1910's, 1940's, 1960's). The cooling intensifying in the 1960's brought to mind that up to the mid-19th century a major supersecular cooling (small glacial epoch) continued which was reflected in the middle latitudes (true, more in winter than in summer), but on a practical basis there was a considerable deterioration of climate in the subpolar regions and the cultivation of crops in the southern part of the temperate latitudes was limited. Some scientists (Flohn, Lamb, and others) began to fear that we were returning to the mentioned cold epoch. It was postulated that in our country the cooling would be accompanied by aridity and that there would be a decrease in the yields of agricultural fields. The latter fear was without basis. The climatic conditions at the end of the small glacial epoch in the 19th century were not worse than those of today for agriculture, but the yields were lower only due to the low technological level of crop cultivation.

Thus, the natural factors and consequences of man's activity at the beginning of the coming century should lead to a warming of climate which will be greater than in the 1930's.

Since a warming has a greater effect on the high latitudes than the low latitudes, a weakening of zonal (westerly and easterly) transports of moisture from the ocean to the continent, strengthening of the effect of meridional components of

atmospheric circulation, some weakening of the temperature contrasts in them, etc., will be associated with them. All this will increase the variability of moistening from year to year and will decrease the quantity of precipitation, especially in winter, in the main agricultural regions, as already occurred in the 1830's-1850's and the 1930's-1950's, but to a still stronger degree. However, with the present-day level of agricultural technology this may not exert such a strong effect on crop yields as in the past. With respect to the subpolar and subtropical regions, there it is possible to expect some increase in moistening. Parallel with the variation in cyclonic activity there will be a change in the frequency of recurrence and strength of storm winds.

It can therefore be postulated that by the beginning of the century climate will warm somewhat in comparison with today's climate. In the north and in the subtropical regions the quantity of precipitation will increase and the wind will intensify and in the temperate latitudes there will be somewhat less precipitation, although its variability will increase from year to year.

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CSO: 1865/248

CLIMATES OF PAST AS A MODEL OF FUTURE CLIMATE

Moscow BROSHYURY IZDATEL'STVA "ZNANIYE": NOVOYE V ZHIZNI, NAUKE, TEKHNIKE, SERIYA "NAUKA O ZEMLE": GEOGRAFICHESKAYA LETOPIS' KLIMATA in Russian No 8, Aug 81
pp 30-32

[Excerpts of article by D. D. Kvasov, doctor of geographical sciences]

[Excerpts] When we get soaked in the dry steppe or suffer from extreme heat in the north the thought involuntarily arises as to whether the climate has begun to change. But on the basis of a single, even the most unusual meteorological phenomenon it is impossible to judge that there has been a change in climate. The climate is the mean state of weather in a particular place on the earth over the course of several decades. During the last 8000-9000 years it has varied only in a small range and essentially the climate of 3000 years ago did not differ from that of today. With the natural course of development of nature climate would also not change in the coming decades.

Man's activity, however, is exerting an ever-increasing influence on the environment. For example, take the production of energy. It is now approximately 0.01% of the energy received by the earth from the sun and exerts virtually no influence on climate. But in the future, as a result of construction of atomic electric power stations the production of energy will increase tenfold. Already at the beginning of the 21st century it can attain 0.1-0.2% of the solar radiation but in the future will rise to 1-2%. Computations show that each percent of additional heat will lead to an increase in temperature by approximately 1°C. The warming is exerting a stronger influence in the polar and temperate latitudes; there is becoming less snow and sea ice in these areas (and these reflect the sun's rays).

Is this good or bad? At first glance it seems that the warming should lead to favorable consequences. But, comment some, will an ecological crisis not develop? Will there not be a drought or a rise in ocean level as a result of the melting of the glaciers in Antarctica and Greenland? In such a case the impending warming would have to be prevented. In the West some have proposed that the growth of the economy be stopped in order to save the environment. The problem is too important to solve it by means of emotions and hypotheses. Detailed investigations and computations must be made.

In the course of the last million years periods when the climate was similar to that of today were repeatedly interrupted by periods when glaciers advanced over enormous expanses of North America, Europe and Siberia. There was a sharp cooling and at the

same time far less rain and snow fell. Mammoths, enormous herbivorous animals, roamed up to the very edge of the glacier, consuming grass scarcely covered with a very thin snow cover. When the glaciers melted and snow became more abundant the mammoths died out rapidly (not without the "assistance" of man).

All this makes probable the assumption that in the future when there is a warming there will be an increase in the quantity of rain. We are very familiar with the pattern that summer heat in the main grain regions of our country causes a drought, evidently effective only for changes in the state of the atmosphere for several months or years, that is, for weather changes. But when the climate changes a different law will probably become operative: warming will lead to an increase in the quantity of rain. Thus, warming will not threaten a drought.

And how will a future warming exert an influence on an increase in ocean level? Those who assume that the possible melting of glaciers in Antarctica and Greenland will lead to an increase in the ocean level by several tens of meters for some reason or another do not take one circumstance into account. Indeed, the glaciers of Antarctica virtually do not melt, but sliding into the ocean, form icebergs. The temperature of January -- the warmest month on the shores of Antarctica -- is less than -4°C . A warming by $2-3^{\circ}\text{C}$ will be almost without importance. The glaciers of Greenland form icebergs and at the same time intensively melt. But they also have a great "safety factor." A warming and an intensification of melting will not lead to a retreat of the glaciers but to a decrease in the number of icebergs.

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CSO: 1865/248

BRIEFS

AEROSOL AND WEATHER FORECASTS--A laser beam which sounds invisible aerosol clouds in the upper layers of the atmosphere has helped physicists of the Belorussian State University in collaboration with meteorologists from Obninsk to develop an effective method for long-term weather forecasting. The accumulations of aerosol, like lenses, change the character of solar radiation that reaches the earth and thereby affect the weather for a long time. While analyzing the behavior of such "lenses," the first movable station of high altitude sounding, which is equipped with receivers for the reflected signals, made it possible to forecast accurately the weather over Belorussia at the important time of the harvest. According to the opinion of scientists, a total of 5 to 10 laser stations would be sufficient to monitor completely the density and movement of aerosol clouds over the country. This would increase greatly the accuracy of long-term weather forecasting. [Text] [Vilnius SOVETSKAYA LITVA in Russian 28 Oct 81 p 3]

CSO: 1865/35-P

LONG-TERM WEATHER FORECASTING--A laser beam which sounds invisible aerosol clouds in the upper layers of the atmosphere has helped physicists of the Belorussian State University in collaboration with meteorologists from Obninsk to develop an effective method for long-term weather forecasting. Accumulations of aerosol, like lenses, change the character of solar radiation which reaches the Earth and thereby influence the weather for a protracted time. While analyzing the behavior of such "lenses," the first mobile station of high-altitude sounding which is equipped with receivers for the reflected signals has helped to forecast accurately the weather in Belorussia opportunely during the harvest. According to the opinion of the scientists, 5 to 10 laser stations would be sufficient to monitor the density and movement of aerosol clouds over the country. This would greatly increase the accuracy of protracted meteorological forecasts. [Text] [Moscow VOZDUSHNYY TRANSPORT in Russian 10 Sep 81 p 4]

CSO: 1865/6-P

UDC 551.58

SIMPLE STATISTICAL MODEL FOR DESCRIBING SPATIAL-TEMPORAL CORRELATIONS OF
MIDDLE-LATITUDE TEMPERATURE FLUCTUATIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 27 Jun 80) pp 805-813

DEMCHENKO, P. F., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] On the basis of a simple zonal model of climate (M. I. Budyko, METEOROLOGIYA I GIDROLOGIYA, No 1, pp 3-12, 1968) with random fluctuations of heat influx, equations are derived for the spatial and temporal correlation functions for middle-latitude temperatures. In the very simple case of a constant heat capacity of the underlying layer (ocean) and absence of an albedo-temperature feedback it was possible to obtain a precise solution which is used in an analysis of the dependence of the latitudinal variation of the dispersions of these fluctuations on the spatial structure of the random influxes and geometry of the problem. The random heat influxes are related to the spatial structure of synoptic temperature fluctuations. Then the model is generalized for the case of presence of two zones with different heat capacities (ocean and ice cover) and the albedo-temperature feedback is taken into account. The computed values of the zonal temperature dispersion in this case agree satisfactorily with their mean climatic values. Figures 1.
[1-5303]

UDC 551.5:551.46

PRELIMINARY RESULTS OF FIRST GLOBAL EXPERIMENT GARP

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 10 Mar 81) pp 787-793

DOBRYSHMAN, Ye. M., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] The principal tasks of the First Global Experiment (FGGE) were as follows: 1. Improvement in an understanding of atmospheric processes for the purpose of refining models of intermediate- and long-range numerical weather

forecasts. 2. Determination of the predictability of the evolution of synoptic systems. 3. Determination of the optimum observation system for routine numerical forecasts. With approach to the FGGE the Global Observation System included more and more different subsystems. The observational part of the FGGE, especially during the special observation periods, actually consisted of three parts. 1. The regularly operating World Weather Watch, including the network of synoptic and aerological stations and groups of artificial earth satellites in polar orbits and five geostationary satellites. 2. Special observation systems, including ships for rawin soundings in the tropics, meteorological research and reconnaissance aircraft, constant-altitude balloons launched into the upper troposphere in the tropics to an altitude of about 14 km, scientific research ships, probes dropped from aircraft, and drifting buoys. 3. Individual types of observations in auxiliary mobile systems carried out under the programs of individual countries or groups of countries in accordance with national plans or regional experiments. It was the totality of measurements with all components of the FGGE observation system which for the first time ensured global coverage. (Figure 2 in the text is a full-page map of the global observation network functioning during the FGGE period.) The initially formulated GARP goal, improvement in weather forecasting, was achieved at all the major meteorological centers. The FGGE played a special role in the analysis and prediction of processes in the southern hemisphere. The FGGE, in whose implementation the representatives of almost 150 countries participated, not only made it possible to solve a number of the formulated problems (some of which are briefly discussed in this article), but specialists in various fields of geophysics made extensive use of FGGE data. Figures 2; references 21: 15 Russian, 6 Western. [1-5303]

UDC 551.57:551.551.5

INFLUENCE OF TURBULENT TRANSFER OF CLOUD DROPLETS ON FORMATION OF CLOUD MICROSTRUCTURE AND PRECIPITATION FORMATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 9, Sep 81 (manuscript received 23 Jun 80) pp 946-955

KOGAN, Ye. L. and MAZIN, I. P., Central Aerological Observatory

[Abstract] On the basis of a three-dimensional model of a cloud, including a detailed description of microphysical processes, the authors give an evaluation of the role of turbulent transfer of cloud droplets in the formation of the droplet-size distribution and precipitation. A series of four experiments was carried out which made it possible to evaluate (upward and downward) the possible role of turbulent mixing of droplets in precipitation-forming processes. In the first experiment it was assumed that condensation is regular and the droplets are not transported by turbulent processes. This case was regarded as the lower evaluation for the dispersion of the real droplet-size distribution. In the second experiment the droplets were transported as a conservative admixture.

The result served as an upward evaluation of the real dispersion. On the basis of the closeness of results for these two experiments it can be concluded that the role of turbulent transfer of droplets in the formation of precipitation is small and there is no need for including unwieldy stochastic condensation equations in a model of convective clouds. In two other experiments in the series it was possible to evaluate the role of turbulent exchange of droplets between the cloud and the surrounding atmosphere. The neglecting of turbulent outflow of droplets radically distorted the pattern of development of a cloud and precipitation. In other words, the results of numerical experimentation were extremely sensitive to the method of description of turbulent mixing of a cloud with the surrounding medium. Therefore, a proper description of turbulent mixing of a cloud with the medium is the principal problem in taking into account the turbulent transfer of droplets in numerical models of convective clouds. Figures 6; references 11: 7 Russian, 4 Western.
[17-5303]

OCEANOGRAPHY

'AYU-DAG' SCIENTIFIC RESEARCH SHIP DESCRIBED

Tallinn MOLODEZH' ESTONII in Russian 25 Aug 81 p 2

[Excerpts from article by G. Golub: "Report From a Floating Laboratory"]

[Excerpts] We went out to inspect the vessel. To be sure, the ship has a bridge and wheel and all the instruments necessary for navigation. However, probably no other ship from among the "colleagues" of the "Ayu-Dag," constructed by Bulgarian ship-builders for short passenger runs, can boast such a fate. It is, after all, one of the best scientific research ships in the Baltic!



"Ayu-Dag" scientific research ship.

Accordingly, alongside the lifeboats on the deck there are winches for lowering instrumentation over the side. At the prow there is a device for the attachment of instruments so that it is possible to see the undisturbed surface and detect the light emanating from the sea. Half the cabin is full of electronic gear. Here are the floating laboratories. But each expedition has its own instrumentation complex.

For the Institute's Baltic Sea Division such a floating laboratory, as they say, is not a luxury, but a vital necessity. The Lokk expedition, for example, worked in five regions: in the Gulf of Finland and the Gulf of Riga, in the northern and southern parts of the Baltic, and in the straits connecting the Baltic Sea with the North Sea. In each of these regions there are different biological and physical conditions and a different composition of the water. This means that by carrying out multisided investigations it is possible to obtain rather complete information concerning the sea.

The objective of this expedition using optical and noncontact methods for investigating the sea was the development of new methods and the perfection of already known methods. But each of the 22 scientists aboard worked on his own theme.

Doctor of Sciences Charlz Villmann and his colleague from the Institute of Physics of the Atmosphere and Astrophysics, Estonian Academy of Sciences, Kal'yu Eerme, studied the optical properties of the atmosphere. Reyn Ryym, of this same institute, has been concerned with support for the current analysis of meteorological observations. Feliks Frishman and Arkadiy Rozenshteyn of the Institute of Thermo- and Electrophysics, Estonian Academy of Sciences, carried out investigations using laser apparatus. Khel'gi Arst has dealt with theoretical computations of light fields. Ol'ga Bekasova of the Biochemistry Institute imeni Bakh, USSR Academy of Sciences, arrived from Moscow specially for work on analysis of phytoplankton.

"The statistical data concerning our expedition are particularly interesting. It consists of 90% males and 10% females. Their average ages are 33 and 31 years, have 1.17 children and 0.82 academic degrees; all speak Russian and 75% speak English; 65% speak Estonian and other languages 0.7%, that is, the average participant is '240.7%' multilingual."

This information is from the expedition's newspaper "KoLOKKol." The "LOKK" part of this title is a play on the name of the expedition's leader (Yaak Lokk). Yaak, incidentally, by no means outwardly resembles a director: even a beard does not contribute to such an impression. However, at age 33 he has 17 years of expeditionary experience behind him!

And now the "Ayu-Dag" is again at sea. It is carrying professional geologists. The next time it will be physicists. And so it will go from May through September.

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CSO: 1865/3

BRIEFS

STUDY OF TURBULENT CURRENTS--A method for simultaneously measuring salinity and electroconductivity of sea water put forth by scientists of Donetsk University may become a key to explaining the secrets of turbulent ocean currents. The apparatus created for this purpose makes it possible to measure characteristics of water masses that are not homogeneous according to temperature and density, and to determine the causes for the changes that arise in them. Measurements will be made using a probe lowered from a ship to a depth of 200 meters. The new device attracted the attention of workers of the Far East Scientific Center of the USSR Academy of Sciences. A group of Donetsk scientists were invited to go to Vladivostok to participate in a joint expedition for investigating the coastal waters of the Pacific Ocean. [Text] [Moscow VODNYI TRANSPORT in Russian 15 Sep 81 p 4]

CSO: 1865/10-P

'KALLISTO' IN SEA OF OKHOTSK--Leningrad geologists who participated in the complex expedition on the scientific research ship "Kallisto" crisscrossed the Sea of Okhotsk three times in different directions. While commentating on the results of the expedition, the director of the section of the All-Union Scientific Research Geologic Institute, V. K. Putinstev, said that the study of the relief and deep construction of the sea's bottom, the composition of the bottom sediments, and outcrops of foundation rocks was done using modern geophysical methods. The data that were acquired are necessary for the creation of a new, large-scale geologic map of the Far East. Different structures ranging from ancient mountain rocks in the west that are several million years old to zones of modern volcanoes in the east will be shown on the map. The Leningrad geologists worked closely with the industrial geologic organizations of the Far East in creating the map. [Excerpt] [Leningrad LENINGRADSKAYA PRAVDA in Russian 10 Oct 81 p 2]

CSO: 1865/31-P

INITIAL STAGE IN EVOLUTION OF ISOLATED EDDY IN SLIGHTLY STRATIFIED OCEAN

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 9, Sep 81 (manuscript received 9 Jul 80, after revision 25 Nov 80)
pp 965-973

KOZLOV, V. F. and KURAKIN, A. Yu., Far Eastern State University

[Abstract] A study was made of the behavior of an initially axisymmetric eddy disturbance in a stratified ocean. The asymptotic method developed by J. Adem (TELLUS, Vol 8, No 3, pp 364-372, 1956) is here extended to the case of a non-linear baroclinic problem. The simplifying assumption is made that the stratification is weak. The ocean, with a horizontal bottom, is modeled when the slightly stratified medium has an internal radius of deformation L_1 and an eddy scale L satisfying the condition $(L_1/L)^2 \ll 1$. This simplification, on the assumption of incompressibility, makes it possible to neglect the vertical advection of density. A solution is obtained in the form of series in powers of the time coordinate. In the case of an initial disturbance of a pressure field of Gaussian form with an arbitrary vertical structure it was possible to find the next three terms of the expansion and also construct the corresponding fields of disturbance of density and vertical velocity. A qualitative analysis of the solution is given. The results give some idea concerning the initial stage in the spatial-temporal evolution of a continuously stratified isolated eddy. A computed example of evolution of a warm anticyclone is given. The advantage of the considered model is a parametric dependence of the solution on the vertical structure and the possibility of taking into account any weak vertical stratifications. It therefore makes sense to attempt to apply it in predicting synoptic variability of appropriate regions of the ocean for times up to 1-1.5 weeks. Figures 1; tables 1; references 13: 4 Russian, 9 Western. [17-5303]

GENERATION OF SURFACE WAVES BY DISCRETE EDDIES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 9, Sep 81 (manuscript received 29 Aug 80) pp 956-964

NOVIKOV, Ye. A., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] Discrete eddies and surface waves are usually considered separately but under natural conditions they interact. The eddies generate waves which in turn exert an influence on the eddies. Accordingly, the author examines the very simple case of a two-dimensional flow of two layers of an ideal incompressible fluid of different density. The linear eddies examined here can exist in both the atmosphere and in the water, and both are considered in detail. This formulation of the problem has made it possible to clarify the physical mechanism of interaction between eddies and waves and in particular, investigate the fundamental mechanism of generation of surface waves by a single eddy. Since discrete eddies arise in nature and are generated during flow around moving bodies, clarification of this fundamental mechanism is of great practical interest and will make it possible to model different phenomena associated with interaction between the ocean and the atmosphere. The author derives a continuous-discrete system of equations for interaction between surface waves and linear eddies. A spectral description of wave development is presented. The form of stationary waves in resonance and nonresonance cases is established. Figures 2; references 4: 3 Russian, 1 Western.

[17-5303]

STATIONARY THREE-DIMENSIONAL WAVES IN FLOW OF STRATIFIED FLUID WITH VELOCITY SHEAR

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 5 Mar 80) pp 888-892

SUVOROV, A. M., Marine Hydrophysical Institute, Ukrainian Academy of Sciences

[Abstract] Within the framework of a simple two-layer model of the ocean the author established in an earlier study (A. M. Suvorov, et al., "Development of Spatial Internal Waves in a Fluid Flow With Velocity Shear," IZV, AN SSSR, FAO, Vol 16, No 6, pp 634-639, 1980) that allowance for the vertical structure of currents can lead to significant changes in the parameters of spatial internal waves. The current velocity in each layer was assumed to be a linear function of depth and a boundary condition filtering surface waves was stipulated at the surface. On the basis of this earlier work the author now has studied forced three-dimensional surface and internal waves in the ocean for adequately arbitrary stable distributions of fluid density and current

velocity with depth. Specific computations of the wave parameters were made for exponential profiles of the density of the fluid and current velocity with depth. This is illustrated in an example with specific values of the parameters. A graph shows the dependence of the limiting angles $\gamma_1 = \max \gamma$ of the first six modes of internal waves on the parameter $d = \exp \chi$, showing by how many times the current velocity at the ocean surface is greater than at the bottom. For each individual mode with an increase in d the limiting angles of the longitudinal internal waves increase, with some d values attaining a maximum value 90° . With transition through these d values a transverse internal wave of the corresponding mode is added to the total wave movement and the limiting angle of this mode decreases with an increase in d . In a general case the total wave movement consists of a finite number of transverse waves and a set of longitudinal internal waves. It is shown that the influence of current velocity shear is substantial. Figures 2; references 7: 6 Russian, 1 Western. [1-5303]

UDC 551.466.81

ATTENUATION OF INTERNAL WAVE SOLITONS DUE TO CYLINDRICAL DIVERGENCE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 11 Mar 80, after revision 13 Jun 80)
pp 886-888

STEPANYANTS, Yu. A., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] In this study of the attenuation of internal wave solitons as a result of cylindrical divergence the author examines a two-layer model of an ocean consisting of a relatively thin surface layer with the depth h and a density ρ_1 and a denser lower layer with the depth $H \gg h$ and the density ρ_2 . Such a model is frequently a good approximation for study of macroscale internal waves since the depth of the upper mixed layer ~ 50 - 100 m is actually small in comparison with the total depth of the ocean and with the characteristic scale of the registered wave disturbances. The dispersion equation for waves at the discontinuity of layers in this model is already known and was used as a point of departure, which leads to an equation for describing the propagation of slightly nonlinear waves travelling in a stipulated direction. This equation in turn has much in common with the Benjamin-Ono and similar equations which would be applicable in such cases under definite conditions. The equation presented here allows solution in the form of solitons. A formula is given for ascertaining soliton energy. The conditions under which the energy of the solitons decreases monotonically are established. Particular attention is given to the cylindrical divergence phenomenon for quasiplane waves distant from a center. A formula is derived making it possible to determine the law of change in amplitude of a soliton with distance. Figures 1; references 7: 2 Russian, 5 Western. [1-5303]

NUMERICAL ANALYSIS OF INFLUENCE OF HYDROPHYSICAL FACTORS ON VERTICAL DISTRIBUTION OF SUSPENDED MATTER AND HYDROOPTICAL CHARACTERISTICS IN OCEAN SURFACE LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 19 Oct 79, after revision 5 Feb 80)
pp 858-866

BURENKOV, V. I., VASIL'KOV, A. P., KEL'BALIKHANOV, B. F. and STEFANTSEV, L. A.,
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[Abstract] In an earlier study (IZVESTIYA AN SSSR: FAO, Vol 17, No 5, pp 537-544, 1981) the authors formulated a system of equations determining the vertical distribution of the concentration of suspended matter and demonstrated the possibility of the existence of nontrivial stationary solutions. Now, on the basis of the preceding investigation, the author gives an analysis of numerical solutions of this system. The purpose of the numerical analysis was a study of the influence of different factors on the vertical distribution of the phytoplankton concentration. Emphasis is on the influence of hydrophysical conditions: turbulent diffusion, upwelling of water and gravitational settling of suspended matter. The materials presented here demonstrate that the position of the local maxima in the vertical profiles of the concentration of suspended matter is not directly related to the position of the layer of maximum water density gradients but is determined by the position of the zone of optimum photosynthesis. The conclusions are based on a theoretical model which does not take into account the great diversity of factors determining the vertical distribution of hydrooptical characteristics. The results apply only to the distribution of living phytoplankton and the presence of other types of suspended matter capable of exerting an influence on the vertical profiles of hydrooptical characteristics, especially detritus, is not taken into account. Nonetheless, the examined model qualitatively correctly reflects the real situation in the ocean. Figures 8; references 6: 5 Russian, 1 Western.

[1-5303]

UDC 551.465.41

STEPPED STRUCTURE OF UPPER THERMOCLINE IN OCEAN

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 22 May 80, after revision 31 Jul 80)
pp 844-848

BELYAYEV, V. S., Institute of Oceanology, USSR Academy of Sciences

[Abstract] Until now there have been few evaluations of the parameters characterizing stratification of ocean waters, especially in the upper part of the thermocline. In this paper the author models the fine structure of the upper

thermocline by a step function with random thicknesses of the steps and random jumps between them. In the case of a Poisson distribution of temperature jumps with depth it was possible to find the distribution law for evaluations of the vertical temperature gradient by the finite differences method. Estimates were obtained for the determining parameters in the model law and it was compared with empirical histograms using measurement data from a polygon in the Indian Ocean surveyed during the 22d voyage of the scientific research ship "Dmitriy Mendeleev." (The polygon, measuring 15 x 15 miles, was situated to the south of Sumatra with measurements being made in the upper 270-m layer.). The materials presented here indicate that the fine structure of the upper thermocline can be adequately described by a step function with definite probabilistic characteristics. It is felt that further investigations should be made in the direction of a search for the dependence of the parameters of the probabilistic distribution laws on background hydrometeorological conditions. Figures 2; references 15: 8 Russian, 7 Western.
[1-5303]

UDC 551.466.31

INVESTIGATING AND COMPUTING ORBITAL VELOCITIES OF IRREGULAR THREE-DIMENSIONAL WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 8, Aug 81 (manuscript received 15 May 80, after revision 24 Jul 80) pp 834-842

MATUSHEVSKIY, G. V. and TRUBKIN, I. P., State Oceanographic Institute

[Abstract] Investigations of irregular wind waves have been quite successful, but the kinematic structure of such waves remains poorly studied and computations of the dynamic loads on ships and hydraulic structures are still based primarily on the theories of monochromatic waves. Analysis of observational data reveals that no version of such theories is capable of giving an adequate representation of the orbital velocities of wave movement. In hydroengineering work it has been demonstrated repeatedly that computations of orbital velocities within the framework of the theory of monochromatic waves gives highly exaggerated or understated values in comparison with actual measurements. However, allowance for the three-dimensionality of waves brings the theoretical results much closer to the measurement results. In this article, on the basis of the mass of accumulated information on the spectrum and statistical properties of wind waves, a study is made of the kinematic structure of waves in deep water and in a shallow-water coastal zone. With allowance for the normal distribution law for the three components of wave movement it was possible to obtain the distribution functions for the absolute values of the vertical and horizontal (vector sum of the longitudinal and transverse components) velocity components. The theoretical conclusions are confirmed by data from field observations. It is shown in examples that the computations of orbital velocities with use of monochromatic wave theory, on the other hand, give a distorted idea concerning the mentioned parameters of wave movement. Figures 3; tables 2; references 18: 10 Russian, 8 Western.

[1-5303]

LIGHT FIELDS IN OCEAN DEPTHS AND CLOUDS WITH ALLOWANCE FOR POLARIZATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 3 Jul 79) pp 820-828

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[Abstract] A study was made of the characteristics of the light regime in the depths of the oceans and cloud layers and formulas and computation methods convenient for these cases are proposed. In the formulated problem the authors examine a plane optically thick or semi-infinite scattering layer whose upper boundary is uniformly illuminated. The examination is limited to the scattering matrix $\hat{A}(\cos \theta)$, θ is the scattering angle, of the simplest form, when the elements $A_{13} = A_{14} = A_{23} = A_{24} = A_{31} = A_{41} = A_{42} = 0$. These conditions, characteristic for a spherically symmetric elementary volume, are always observed for droplet clouds. The optical properties of sea water in a number of cases are described quite well by such a scattering matrix. With this taken into account, the authors have derived asymptotic formulas for the Stokes parameters and the attenuation index in a deep regime in the region of weak absorptions and have formulated an algorithm for computing these parameters in the case of arbitrary absorption. The characteristics of light fields in a deep regime are given for the scattering matrices for a cloud and the experimentally measured sea water matrices. It is shown that in computing the energy of light fields the influence of polarization can be neglected. It is noted that in the sea there can be considerable polarization when the light has a considerable intensity, but there is no realistic possibility for using polarization measurements in a deep regime for ascertaining the parameters of the scattering matrix. Figures 3; tables 2; references 19: 17 Russian, 2 Western.

[1-5303]

UDC 911.2:551.46

REVIEW OF 'ATLAS OF THE OCEANS, VOLUME 1: PACIFIC OCEAN, 1974; VOLUME 2: ATLANTIC AND INDIAN OCEANS, 1977' (ATLAS OKEANOV, T 1: TIKHIY OKEAN, 1974; T 2: ATLANTICHESKIY I INDIYSKIY OKEANY, 1977)

Leningrad IZVESTIYA VSESOYUZNOGO GEOGRAFICHESKOGO OBSHCHESTVA in Russian
Vol 113, No 5, Sep-Oct 81 pp 452-455

ASLANIKASHVILI, A. F.

[Abstract] The atlas reviewed here constitutes one of the most outstanding productions in the history of world cartography. The two volumes, compiled and edited by outstanding scientists, bring together all the scientific knowledge of this and preceding generations. In the atlas the world ocean is

considered to consist of four principal subsystems, examined both individually and in their interrelationship to one another. Each subsystem is dealt with in the corresponding chapter of the atlas: the oceanic lithosphere is dealt with in the chapter "Ocean Floor," the oceanic atmosphere in the chapter "Climate," the oceanic hydrosphere in the chapter "Hydrology" and the oceanic biosphere in the chapter "Biogeography." Each chapter is preceded by unique historical materials. For example, there is an extensive set of maps "Most Important Voyages and Oceanographic Expeditions." There is a detailed description of the most important oceanographic expeditions of four different periods (1872-1914, 1919-1936, 1946-1956, 1957-1960), international and foreign expeditions of 1961-1970 and Soviet oceanographic expeditions of 1961-1975. Oceanographic data of a reference or navigational character is presented in the last, lengthy chapter of the atlas. Each of the chapters in the book is reviewed. Maps of every conceivable theme related to the oceans are included, extending down to maps of such interest to navigators as "twilight," "time zones," "solar system," "night sky" and "moon." Maps of sea and air communication lines are included and there is a full description (textual and cartographic) of the world's principal ports and airports. In brief, the atlas incorporates all the reliable scientific knowledge accumulated by man during the entire period of his social and practical activity related to the oceans.

[32-5303]

UDC 551.224(265)

SEA OF OKHOTSK EXPEDITION OF 'MORSKOY GEOFIZIK' SCIENTIFIC RESEARCH SHIP
(15TH-16TH VOYAGES, 1980)

Moscow OKEANOLOGIYA in Russian Vol 21, No 5, Sep-Oct 81 pp 937-939

ANDREYEV, A. A., KRASNYY, M. L., SAPOZHNIKOV, B. G. and KHVEDCHUK, I. I.

[Abstract] During the period 1 June-30 August 1980 an expedition was carried out in the northern part of the Sea of Okhotsk aboard the scientific research ship "Morskoy Geofizik" (15th-16th voyages) by the Sakhalin Multidiscipline Scientific Research Institute in collaboration with the Pacific Ocean Marine Geological-Geophysical Petroleum and Gas Expedition of the All-Union Marine Scientific Production Combine for Petroleum and Gas Exploration. The investigations were carried out by a complex of geophysical methods, including gravimetry, magnetometry, continuous seismic profiling by the central ray method, and also depth measurements. The ship was outfitted with a satellite navigational system. The objective of the expedition was a determination of the structural plan of the basement, the thickness of the sedimentary complex, the areal and spatial distribution of density and magnetic inhomogeneities and geomorphological features of the investigated regions of the Sea of Okhotsk. The choice of features was dictated primarily by the very poor geophysical study of the Shantar'skiy and Kamchatskiy polygons (a map accompanies the text) and their key position relative to structural complexes of different age exposed within the limits of the continent, Kamchatka Peninsula and Sakhalin Island.

Preliminary results from an analysis of these materials made it possible to draw some preliminary conclusions concerning a number of structural zones of the Sea of Okhotsk floor whose strike and characteristics were not known earlier. Figures 1.

[29-5303]

UDC 551.462

DISCRIMINATING LATERAL WAVES IN SEISMIC PROFILING OF OCEAN FLOOR BY REFLECTED WAVES METHOD

Moscow OKEANOLOGIYA in Russian Vol 21, No 5, Sep-Oct 81

(manuscript received 26 Feb 80, after revision 11 Jun 80) pp 921-926

GOL'MSHTOK, A. Ya. and KOGAN, L. I., Southern Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Gelendzhik

[Abstract] When carrying out seismic profiling by the reflected waves method under conditions of dissected relief of the ocean floor and deep discontinuities the seismic sections contain records of reflected and diffracted waves from features lying outside the observation plane (lateral waves). With the use of low-frequency sources of excitation of elastic waves and accordingly low-frequency reception systems (5-30 Hz) the lateral waves from remote features are registered and traced along the profile line for considerable distances. Due to the complex geometry of the reflecting features the discrimination of lateral waves is sometimes very difficult and there can be an erroneous interpretation when the lateral waves from bottom irregularities are taken to be deep waves. In this article as a criterion for identification of lateral water waves the authors propose use of a comparison of the time difference in the arrival of single and multiple waves in the water layer, which under the conditions prevailing in the ocean are easily traced and registered on seismic profiling time sections. By means of theoretical computations it is demonstrated that the difference in the arrival time for single and multiple waves in the water layer for deep waves will be greater than for lateral waves and this discrepancy increases with an increase in the absolute arrival time of the reflections. A specific sequence of operations is proposed for discriminating deep and lateral waves. Figures 3; tables 1; references: 4 Russian.

[29-5303]

ONE MODEL OF SEA MEDIUM ALLOWING EVALUATION OF FLUCTUATIONS OF ACOUSTIC SIGNALS IN CASE OF MULTIRAY PROPAGATION

Moscow OKEANOLOGIYA in Russian Vol 21, No 5, Sep-Oct 81
(manuscript received 24 Jul 80, after revision 8 Jan 81) pp 808-813

SELIN, Ye. A. and FOKIN, A. V., Institute of Oceanology imeni P. P. Shirshov, Moscow

[Abstract] Munk proposed the use of acoustic signals for investigating macro-scale inhomogeneities in the ocean such as eddies and currents. In this case the basic information is carried by fluctuations in the time of propagation of acoustic signals along different rays passing through regions occupied by these inhomogeneities. The routine evaluation of these fluctuations, the same as fluctuations of the glancing angles and the amplitudes of signals at the observation point, can be accomplished using the method described in this article. In this method the medium is represented in the form of a fluid layer bounded by the planes $z = 0$ and $z = h$. It is assumed that the acoustic properties of the layer are determined by the reflection coefficients $V_0(\alpha)$ and $V_h(\alpha)$ at the boundaries and the distribution of the speed of sound $c(x, z)$. There is no variability of the speed-of-sound field along the y axis. It is assumed that the function $c(x, z)$ is represented in the form of the sum $c(x, z) = c_0(z) + \delta c(x, z)$, where $c_0(z)$ is the undisturbed field dependent only on one coordinate and $\delta c(x, z)$ is a small disturbance dependent on two coordinates. Two points are discriminated in this medium: radiation point and observation point. It is necessary to determine the rays connecting these points and the parameters of these rays, specifically, propagation time, focusing factor and glancing angles at the source and observation point. A specific example is cited for illustrating application of the method. Figures 3; references 6: 2 Russian, 4 Western.
[29-5303]

REACTION OF BAROCLINIC OCEAN TO TROPICAL CYCLONE

Moscow OKEANOLOGIYA in Russian Vol 21, No 5, Sep-Oct 81
(manuscript received 1 Jul 80, after revision 17 Nov 80) pp 794-801

GINIS, I. D. and DIKINOV, Kh. Zh., Kabardino-Balkarskiy State University, Nal'chik

[Abstract] A study was made of the reaction of a stratified ocean to the distribution of wind stress with a center fixed relative to the ocean. The evolution of the track of a tropical cyclone after its withdrawal from the considered region is also described. Current velocities in the upper homogeneous

layer and the thermocline were computed, as well as the vertical distribution of ocean temperature as a function of distance to the center of the region and time. The following picture was established. In the initial period of wind impact in the upper quasihomogeneous layer there is a convergent cyclonic circulation and intensive turbulent mixing which are accompanied by entrainment of water from the thermocline. After six hours the radial component of current velocity in the upper quasihomogeneous layer changes sign as a result of operation of inertial forces. The developing Ekman transfer causes ascending vertical movements in the central part of the region and descending movements on the periphery. The surface $z = \xi_2$ rises at the center together with the fluid, whereas the surface $z = \xi_1$ sinks, since the rate of entrainment exceeds the rate of upwelling ($z = \xi_1$ and $z = \xi_2$ are the discontinuities between the upper quasihomogeneous layer and the thermocline, the thermocline and the abyssal region). After removal of the wind stress turbulent mixing in the upper quasihomogeneous layer ceases at the ocean surface and the surface $z = \xi_1$ also begins to move together with the fluid. Vertical movements of the thermocline lead to a shifting of the isotherms and as a result to the appearance of a convergent cyclonic circulation in this layer. As a result, a circulatory cell is formed. By the end of the first 24 hours in the zone where the wind velocity in the tropical cyclone was maximum the temperature experiences the sharpest changes with transition from the upper quasihomogeneous layer to the thermocline. The mean displacement of the isotherms from the initial horizontal position is 60 m. In the upper 200-m layer of the ocean 24 hours after onset of the process there was a deviation of temperature from its initial value; it is easy to trace a zone of anomalously low temperature in the neighborhood of the center of the region, arising as a result of upwelling. The minimum temperature in this zone is 2°C lower than the background level. The observed cooling of the upper quasihomogeneous layer is caused primarily by mixing with the lower-lying thermocline during operation of the tropical cyclone. There is a zone with positive temperature anomalies where the water of the upper homogeneous layer has penetrated into the region of the former thermocline. Below the warming zone there is again a cooled region forming as a result of upwelling. Subsidence of waters on the periphery of the region leads to a slow deepening of the lower boundary of the thermocline $z = \xi_2$ and as a result to a warming of the entire baroclinic layer in this zone. Figures 6; references 9: 6 Russian, 3 Western.

[29-5303]

UDC 551.463(263)

DYNAMIC-STOCHASTIC MODEL OF DENSITY FIELD IN APPLICATION TO ANALYSIS OF OBSERVATIONS IN TROPICAL ATLANTIC

Moscow OKEANOLOGIYA in Russian Vol 21, No 5, Sep-Oct 81
(manuscript received 27 Jun 80) pp 787-793

TIMCHENKO, I. Ye., KHLOPUSHINA, S. I. and KNYSH, V. V., Marine Hydrophysical Institute, Ukrainian Academy of Sciences, Sevastopol'

[Abstract] Objective analysis of observations at stations has been the traditional method for plotting maps of atmospheric and oceanic fields. Based

on a probabilistic mathematical model of the field, this method ensures an interpolation of measurements at the points of intersection of a grid covering the studied region which is optimum in accuracy. In oceanology, however, the field of applicability is limited because real oceanic fields are not uniform and isotropic and also due to the inadequate number of oceanological stations, asynchronicity of measurements, and other factors. The authors here demonstrate that these limitations can be considerably modified by ensuring quasisynchronization of measurements and computing the averaged fields for those moments in time when optimum interpolation is carried out. In order to satisfy these conditions it is necessary to use thermohydrodynamic models approximately describing the dynamics of fields in the investigated region. The combination of numerical models of dynamics of the ocean with an optimum interpolation algorithm constitutes a dynamic-stochastic approach to the analysis of observations. (This approach was laid out by B. A. Nelepo and I. Ye. Timchenko in *SISTEMNYYE PRINTSIPIY ANALIZA NABLYUDENIY V OKEANE* (Systemic Principles for Analysis of Ocean Observations), Kiev, Naukova Dumka, 1978.) A similar approach was used in an analysis of density surveys in hydrophysical polygons (for example, see V. V. Knysh, et al., "Dynamic-Stochastic Approach to Analysis of Density Field Observations in Hydrophysical Polygons," *IZV. AN SSSR: FIZIKA ATMOSFERI I OKEANA*, Vol 14, No 10, pp 1079-1093, 1978). With this previous experience taken into account, the authors apply it in an investigation of macro-scale fields in the tropical Atlantic. However, in contrast to the processing of polygon measurements, such as used in earlier studies, use is made of multiple assimilation of data in a dynamic-stochastic model. The observations used were hydrological data collected in the tropical Atlantic in the EQUALANT program. In this example it is shown that the use of a dynamic-stochastic model for the assimilation of observational data on density fields in the tropical Atlantic made it possible to plot the level field and the fields of density, horizontal and vertical current velocities on the basis of asynchronous observations distributed nonuniformly in area. Figures 4; references 17: 16 Russian, 1 Western. [29-5303]

UDC 550.834(571.5)

METHOD FOR SEISMIC INVESTIGATIONS OF BASEMENT IN SOUTHERN SIBERIAN PLATFORM

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 8, Aug 81
(manuscript received 12 Feb 80) pp 83-92

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[Abstract] In the regional study of the basement surface of the Siberian Platform by point seismic soundings using refracted waves problems arise which are associated with the specifics of the seismogeological conditions in this region. Among the important features of this region are an insignificant difference in mean velocity in the sedimentary cover (4.8-5.4 km/sec) and the boundary velocity at the basement surface (5.9-6.2 km/sec) and also the presence in the sedimentary cover of high-velocity (6.4 km/sec) layers with a thickness of 100-200 m. As a result, the wave refracted at the basement surface appears in the first arrivals at great distances from the source of oscillations; this distance exceeds by a factor of 15-20 the depth of the studied boundary. In this region with a thickness of the sedimentary cover of 1.5-2.5 km the reliable registry of a wave from the basement surface in the first arrivals is possible when soundings are made from bases (shot-reception distances) of not less than 25-30 km. With a simplified approach to interpretation of soundings the mean depths and mean boundary velocities are determined on the assumption of a plane refracting discontinuity and a constant boundary velocity along the entire sounding base. Under these conditions for the registry of refracted waves the effects of averaging along long bases can lead to considerable distortions of the results which cannot be neglected even in the stage of regional work. Accordingly, the author has examined methods for localizing determinations of depth and boundary velocity values. Relatively simple sounding systems are proposed which in the interpretation make it possible to exclude the effect of averaging the determined parameters along long bases. These methods are being checked in a theoretical model and on the basis of field data. (The least squares method for accomplishing such an objective, proposed by A. E. Sheidegger, et al. in GEOPHYSICS, Vol 22, 1957, is considered impractical.) The proposed system calls for three, five or any odd number of soundings to be coupled together for arriving at a reliable value of the desired parameters. The advantages of symmetric and asymmetric placement of these sounding points

along the profile are considered. The several proposed variants all make it possible to scale the time field to short bases. Figures 6: 5 Russian, 1 Western,
[33-5303]

UDC 550.344

CORRELATION OF MAXIMUM EARTHQUAKE ENERGY WITH ABSORBING AND SCATTERING
CHARACTERISTICS OF SEISMOGENIC LAYER AND ASTHENOSPHERE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 259, No 6, 1981
(manuscript received 2 Mar 81) pp 1333-1337

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[Abstract] The characteristics of the seismic regime, especially the maximum energy of a possible earthquake (magnitude M_{\max}) can differ substantially even in relatively near seismically active regions. In order to establish the factors responsible for these differences it is important to study the physical properties of the medium associated with variations in the level of seismic activity. The author therefore investigated the absorbing and scattering characteristics of the seismogenic layer and the upper mantle in regions with different M_{\max} values. Studies were made of the following regions of the Asiatic continent: Northern Tien Shan, Gissarskiy Range, Peter I Range, Eastern Kazakhstan, Tadzhikskaya Depression, Southern Kuriles, Kamchatka and Central Japan. These regions are characterized by great variations in the level of seismic activity and maximum earthquake energy: the M_{\max} values vary from 5.5 to 8.5-8.8. (As a comparison the author also cites data on lunar absorption and seismicity.) These regions belong to different geotectonic zones. It is postulated that the greatest influence on the course of tectonic processes is exerted by physical characteristics of the seismogenic layer in which the release of seismic energy occurs and the mobile layer in the upper mantle (asthenosphere). As the seismogenic layer the author used: the crust in Central Asia, the layer 25-300 km on the moon and the focal layer to a depth as great as 80 km on the Pacific coast. The layers at depths of 100-200 km in Central Asia, 300-400 km on the moon and 80-160 km in the Pacific Ocean were used as the asthenosphere (these approximately correspond to the position of the waveguides in the upper mantle of these seismically active regions). An evaluation of the absorption and scattering coefficients for different regions of the Asiatic continent is given on the basis of records of local earthquakes. It was found that the principal factor determining the M_{\max} value is a combination of the physical properties of the medium associated with great absorption in the asthenosphere and small scattering in the seismically active layer. The significant correlation between the absorption and viscosity coefficients indicates that high M_{\max} values are characteristic of regions with a reduced viscosity of the upper mantle in which there can be high rates of deformation. However, this necessary condition is not adequate: with a great inhomogeneity and low viscosity of the seismogenic layer the dilatational stresses are not in the form of infrequent and strong

tremors, but in the form of a great number of weak earthquakes. The discovered dependence of the level of seismic activity on the state of the upper mantle can be evidence of an important role of vertical movements in the formation of the tectonic pattern in the considered regions. Figures 3; references 15: 12 Russian, 3 Western.
[4-5303]

UDC 551.241.52(571.1)

GEOLOGICAL STRUCTURE OF WEST SIBERIAN PLATE BASEMENT

Moscow GEOTEKTONIKA in Russian No 5, Sep-Oct 81
(manuscript received 14 Mar 80) pp 64-70

BENENSON, V. A., Institute of Geology and Regional Geological Prospecting,
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[Abstract] Investigation of geological structure of the West Siberian Plate basement is one of the most important tasks for understanding its geotectonic position. In addition to the scientific-theoretical aspect, this undertaking is timely because commercial flows of petroleum and gas have been obtained in recent years from the Carboniferous and Devonian deposits in Western Siberia. The author has therefore generalized the results of seismic and geological data of recent years. These new materials make it possible to reexamine earlier concepts concerning the dominant role of Hercynian folded structures in the basement of internal regions of the West Siberian Plate. Figure 1 is a full-page map of the relief and boundary velocities along the basement surface. The generalization reveals that within the limits of the investigated territory there are two regions with different basement structure: northern (Nadym-Tazovskiy), extending into the region of the Yamal and Gydan Peninsulas, and southern, to the south of latitude 64° . The northern region is evidently characterized by basic and ultrabasic composition of the basement rocks, a "granite-free" structure of the earth's crust, which probably reflects a suboceanic structural type. This part of the territory corresponds to a region of intensive downwarping and accumulation of a great thickness of sediments of the Triassic-Paleozoic and Jurassic-Neogene complexes. In the southern part of the territory there is an alternation of major blocks of the basement with acidic rocks predominating in some and basic rocks predominating in others. Within the limits of some blocks there are local sectors, crustal "windows," close in crustal composition to the oceanic type. In the basement relief there is a predominance of isometric regions and partially elongated zones in the basement relief differing appreciably from the linear dislocations of Hercynian geosynclines. During the Pre-Jurassic period these regions and zones were subjected to magmatic reworking and a relative fragmentation by block movements. However, with respect to character of manifestation these processes differ appreciably from those which are usually characteristic for the Ural and Tien Shan type of paleozoids. It is concluded that in most of the internal regions of the West Siberian Plate Paleozoic deposits were formed under conditions in many respects

differing from geosynclinal. The new geological-geophysical data therefore require changes in past concepts concerning basement structure in this region and recognition of the dominating role of blocks of the Pre-Paleozoic consolidation in its structure. Figures 1; references: 13 Russian.
[18-5303]

UDC 550.834(571.63)(571.64)

LONGITUDINAL WAVE VELOCITIES IN SEDIMENTARY COMPLEX ROCKS ON SHELF OF SOUTHERN PRIMOR'YE AND SOUTHWESTERN SAKHALIN

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 9, Sep 81 pp 76-82

ZHURAVLEV, A. S., KOLESOV, S. V., KONOVALOV, V. V. and MAZIRKA, V. M.,
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[Abstract] The velocities of longitudinal waves in rocks of the sedimentary complex were investigated by specialists of the All-Union Scientific Research Institute of Marine Geology on the shelf of southern Primor'ye in 1972-1977 and along the western shores of Sakhalin in 1978. Vertical seismoacoustic profiling was carried out in shallow boreholes drilled during geological engineering or mapping work. Studies were made in 23 boreholes. Seven sectors in southern Primor'ye and one in the Sakhalin region were studied. The sectors were in shallow waters, mostly near the shore, in semiclosed bays protected against the waves. The results of these studies are summarized in three tables. It was found that in Primor'ye the section can be described by a two- or three-layer model; on the shelf of southwestern Sakhalin the section is two-layered. Errors in determining stratum velocities averaged 3-4% (maximum not more than 15%). Large velocity jumps were associated with a change in the density and lithological composition of the rocks. The mean velocities conform to a dependence of the type $V_{\text{mean}} = a + bt^2$. The values of the a and b coefficients are dependent on the sector where the work was done because the thicknesses of the strata and the stratum velocities change appreciably along the strike. These dependences can be used in interpreting records of continuous seismoacoustic profiling. The results of this investigation reveal the possibility of a lithological-stratigraphic breakdown of deposits of the unconsolidated shelf deposits of southern Primor'ye on the basis of velocity differentiation of sediments. Tables 3; references: 4 Russian.
[11-5303]

NEW DATA ON CRUSTAL STRUCTURE OF SHATSKIY RISE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 259, No 4, 1981
(manuscript received 26 Jun 80) pp 922-926

KOGAN, L. I. and SHMIDT, O. A., Southern Division, Institute of Oceanology,
and Geological Institute, USSR Academy of Sciences

[Abstract] In 1978, during the 21st voyage of the scientific research ship "Dmitriy Mendeleev," specialists carried out multichannel seismic profiling along a profile intersecting the northwestern basin and northwestern part of the Shatskiy Rise (Fig. 1 is a bathometric chart of this area). The effective depth and high resolution of the deep seismic profiling method made it possible to determine not only the thickness of the principal crustal layers, but also for the first time to discriminate their structural elements, thus making it possible to draw new conclusions concerning the genesis of the Shatskiy Rise. In the processing and interpretation of these data use was made of statistical modeling on an electronic computer. Comparison of experimental and synthetic seismograms made it possible to explain the wave pattern. The absence of extensive (more than 0-15 km) reflecting boundaries observed in this area is attributable to acoustic and structural nonuniformities in structure of the main layers of the earth's crust. Statistical modeling made it possible to obtain the most probable models of structure of the crust in the Shatskiy Rise. The studied profile intersects the foot, scarp and northwestern part of the Shatskiy Rise. Each of these sectors has a specific crustal structure. In the basin, at the foot of the rise, there is a typical structure of an oceanic crust. Layer I, the sedimentary layer, has a thickness of 0.5-0.6 km. Layer II is divided into two parts. The upper part, with a thickness of 0.7-1.5 km, is best approximated by a model representing continuous intercalation of lenticular bodies with an extent from 1 to 4 km. The lower part, with a thickness of 2.0-2.2 km, is characterized by an extent of lenticular bodies up to 4-6 km. Layer III has upper and lower parts with thicknesses 2.6-3.0 and 2.1-3.1 km respectively. A block structure best of all reflects the wave pattern observed here; the extent of the blocks is 5-7 km. In the scarp zone there is no sedimentary layer and a marked increase in the thickness of layers II and III to 6.0 and 8.1 km respectively. In the segment of the profile intersecting the northwestern part of the Shatskiy Rise the crust has a complex structure. Layer I has a thickness up to 1.2 km. There is a transitional layer between layers I and II with a thickness as great as 2.0 km represented by an intercalation of lenticular bodies with an extent from 5 to 15 km. Layer II has a thickness from 2.9 to 5.6 km. The most applicable statistical model is a block structure. The thickness of layer III is 6-7 km and a block model corresponds to the observed wave pattern. Thus, deep seismic profiling with the use of statistical modeling for the interpretation of these data made it possible to clarify the structure of the principal crustal layers and the absence of extensive reflecting boundaries in the Shatskiy Rise. Figures 4; references 10: 8 Russian, 2 Western.

[252-5303]

INVERSE PROBLEM OF DEEP ELECTROMAGNETIC SOUNDING OF EARTH

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 24 Jul 80) pp 715-719

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[Abstract] Despite a considerable increase in the volume of experimental data on global electromagnetic sounding of the earth, it still has not been possible to clarify the details of the distribution of conductivity with depth. The interpretation of these data is difficult largely due to three factors: considerable dispersion of experimental determinations of apparent resistivity ρ_T , limitations on the frequency range and inadequate certainty concerning a priori concepts on the nature of the distribution of conductivity with depth. Repeated attempts to select the best distribution of conductivity have led to the formulation of a great many models. In general, all are consistent with experimental data, but are determined by a great number of parameters and are not convenient for everyday work. For this reason it was deemed important to formulate a very simple (standard) model of conductivity which would correctly describe the character of change of conductivity with depth, which would conform well to experimental data and would contain a minimum of parameters. Such a model could be used conveniently as a background model for discriminating well-conducting crustal and magnetic layers and in the mathematical modeling of electromagnetic induction in inhomogeneous media. The model developed is the power-law distribution $\rho = \rho_0 h^\gamma$, where ρ_0 is resistivity at the top of the medium lying under the first sedimentary layer whose thickness is h_0 , h is dimensionless depth, expressed in thicknesses of the sedimentary layer ($h \geq 1$). The choice of the power-law model was dictated primarily by its simplicity: it contains only two parameters, ρ_0 and γ . Computations of the parameters of the power-law model for the East European Platform gave the values $\rho_0 = 0.74 \cdot 10^9$, $\gamma = -3.016$. The model $\rho = 0.74 \cdot 10^9 h^{-3.016}$ must be regarded as the normal section for the East European Platform and the corresponding ρ_T curve must be regarded as the sounding curve normal for this region. Similar models can be constructed for different tectonic structures: continental and oceanic platforms, geosynclinal, oceanic and orogenic mobile zones. Figures 1; references 17: 9 Russian, 8 Western. [244-5303]

MODEL OF NONSTATIONARY TEMPERATURE FIELD OF EARTH'S CRUST IN BAYKAL RIFT ZONE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 7, Jul 81
(manuscript received 19 May 80) pp 3-14

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[Abstract] In order to develop further the concepts concerning the nonstationary character of the thermal field in the Baykal rift zone, the authors examine a two-dimensional variant of a geothermal model which takes into account the presence of both a regional (broad asthenospheric diapir) and a local (fissure intrusion in the crust) heat source. The model, illustrated in Fig. 1, is fully described. The modeling was carried out for a lithospheric block with a width of 550 km and a thickness of 120 km. This block corresponds to a theoretical section which intersects the rift zone across its strike and takes in part of the Siberian platform and part of the Transbaykal region of moderate mountain formation. No effort was made to introduce the customary simplifications; allowance was made for such factors as the finite dimensions of the asthenospheric diapir, relief of the Mohorovicic discontinuity, existence of lenses of sediments in the rift depression and the release of heat by radioactive elements. It is assumed that heat transfer in the lithosphere occurs primarily by conduction. This relatively complex variant of the geothermal model is realized using numerical methods for solution of the heat conductivity equation on an electronic computer. This model of the nonstationary temperature field made it possible to collate geothermal data with earlier published information concerning the deep structure of the rift zone, the sequence of geological events and processes in the upper mantle which led to the formation of the most recent geological structure of this region. The model can be used in predicting the temperatures in depth, which is necessary for the planning of drilling of deep boreholes and in an analysis of the processes transpiring in riftogenesis in the deep parts of the crust; earlier models did not afford such a possibility. Figures 1; tables 3; references: 18 Russian.
[239-303]

EFFECT OF WORLD OCEAN ON RESULTS OF GLOBAL MAGNETOVARIATION SOUNDING

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 7, Jul 81
(manuscript received 16 Dec 80) pp 61-67

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[Abstract] Investigations of the influence of the world ocean on determination of the spectral impedances used for global magnetovariation sounding are now

particularly timely. However, the problem of the vulnerability of such data to the distorting influence of macroscale near-surface conductivity inhomogeneities of the world ocean and continental types remains open. (Usually in global magnetovariation sounding use is made of a spherically symmetric model of the earth and the influence of near-surface inhomogeneities is considered insignificant or is not taken into account.) The objective of this study, in essence, was to answer the question: are the distortions of geomagnetic variations caused by regional near-surface conductivity inhomogeneities smoothed by spherical harmonic analysis adequate or must there be special allowance for the influence of inhomogeneities on spectral impedances? The analysis of this problem led the authors to the following conclusions. 1) The distorting influence of near-surface conductivity inhomogeneities, especially the world ocean, exerts an appreciable influence on the determination of spectral impedances and the results of global magnetovariation sounding in periods up to 24 hours. These distortions can attain several tens of percent for apparent resistivity and tens of degrees for the impedance phase. 2) With an increase in the period of the investigated disturbances the distorting influence of the near-surface inhomogeneities gradually attenuates. For D_{st} variations these distortions do not exceed several percent for periods $T = 48$ and 72 hours. 3) The low vulnerability of D_{st} variations to the distorting influence of near-surface conductivity inhomogeneities indicates the desirability of constructing the high-frequency branch of the global sounding curve on the basis of data on D_{st} variations. Figures 2; references 20: 8 Russian, 12 Western. [239-5303]

UDC 550.382.4

ELECTROMAGNETIC FIELD CREATED DURING MOTION OF SPHERE IN PERMANENT MAGNETIC FIELD

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian, No 7, Jul 81 (manuscript received 27 Dec 79) pp 92-98

SOCHEL'NIKOV, V. V. and BATSANIN, S. F., Southern Division, Institute of Oceanology, USSR Academy of Sciences

[Abstract] An increase in the accuracy of measurement of strength of the natural electromagnetic field in the sea requires an evaluation of different kinds of noise. One of the possible types of noise is the electromagnetic field induced by motions of the carriers of sensors (ship, magnetometer gondola) in the sea in the permanent magnetic field. The electromagnetic field arises both due to motion of the conducting carrier and due to perturbation of the flow of conducting fluid around it. In the first approximation the arising effects can be evaluated in the example of a sphere moving in a homogeneous medium. (It is assumed that a sphere of the radius a moves with the constant velocity v_0 in the permanent magnetic field F .) The authors derive final expressions for the components of the induced magnetic field and then for the electric field in fixed and moving coordinate systems. It is shown that no

electric field is induced due to the F_y component along the direction of motion of the sphere. The electric field induced by the F_z component perpendicular to the direction of motion has the following structure. Within the sphere the field is uniform and is not dependent on the dimensions of the sphere. Outside the sphere there is a field of an electric dipole with a specific moment. Under the influence of the F_z component there is a separation of charges in the sphere and in the fluid. The charges are accumulated on the surface of the sphere, which behaves as a uniformly polarized body. The electric field of a uniformly polarized sphere is uniform but outside is equivalent to the field of an electric dipole. A magnetic field is created by the currents of the moving electric dipole, the uniform currents within the sphere and also the currents arising in the fluid due to the Lorenz force. Accordingly, the structure of the induced magnetic field differs from the structure of the magnetic field of a moving electric dipole. Formulas are derived which make it possible to compute all the components of strength of the induced electric and magnetic fields. The maximum values are estimated. Figures 1; references: 2 Russian. [239-5303]

UDC 550.38;550.8

MEASUREMENT OF TENSOR OF REVERSIBLE MAGNETIC SUSCEPTIBILITY OF ROCKS BY ASTATIC MAGNETOMETER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 7, Jul 81
(manuscript received 3 Mar 80) pp 99-108

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[Abstract] Magnetic anisotropy is being used more and more extensively in the solution of different geological problems. The success of this type of investigations is determined to a considerable degree by the degree to which the measurement method is adequate to the tensor value. The author here examines the theory and practice of measurements of the tensor of reversible susceptibility with an astatic magnetometer. The desirability of developing a method specifically for the astatic magnetometer is attributable to the fact that the MA-21 is in standard production and is the most widely used instrument. Following formulation of the problem and derivation of the fundamental working formulas, the article examines in detail the problems involved in the measurement of the tensor of reversible magnetic susceptibility of rocks in the presence and absence of remanent magnetization. The different factors involved in errors in measurement of the tensor are considered in depth and specific examples of such measurements are presented. The author demonstrates that reversible susceptibility, in contrast to irreversible susceptibility, is a tensor in the strict sense of the word and this makes it possible with greater accuracy to determine the characteristic parameters and direction of anisotropy. The productivity of measurement of the tensor of reversible susceptibility is three times greater than productivity of measurement of the tensor of irreversible susceptibility. In addition, it does not require an apparatus for the magnetization of samples

with a permanent field. Figures 2; tables 2; references: 7 Russian, [239-5303]

UDC 550.344

METHOD FOR COMPUTING STRONG MOVEMENT DURING EARTHQUAKE (DEVELOPMENT OF STATISTICAL MODEL)

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 81 (manuscript received 16 Nov 79) pp 41-54

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[Abstract] A method is proposed for computing strong movement in an earthquake. The method takes into account the local conditions prevailing in seismically active regions. In computing the seismograms an important role is played by the focal mechanism of the earthquake, on which are dependent the extent of the focus (with a given magnitude), velocity of dislocation propagation and law of radiation of incoherent power. The intensity registered on the seismogram can be broken down into a regular (focal) component and the scattered component, generated by medium inhomogeneity. Computation of medium response for an elementary subsource has been formalized; it was assumed that the regular component attenuates as a result of geometrical divergence, absorption and scattering, whereas the scattered component attenuates as the general coda envelope. The authors present an algorithm for computing strong movement which involves computing the envelopes of ChISS seismograms, filling them with quasiharmonic components (sine curves with fluctuating frequencies) and summation in the frequency range of interest. The complexity of computing the field of short-period oscillations in the near zone required the introduction of a number of simplifying assumptions, such as use of a one-dimensional model of the focus. The proposed scheme for computing strong movement must therefore be regarded as a first approximation which can be improved upon in the future. Figures 1; references 37: 30 Russian, 7 Western. [8-5303]

EVALUATING EFFECTIVENESS OF NEW CRITERIA FOR TSUNAMI-GENERATING EARTHQUAKES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 81
(manuscript received 28 Oct 80) pp 25-40

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Sciences

[Abstract] According to the teaching data employed by the authors (32 earthquakes generating tsunamis, 36 events which did not produce tsunamis), the effectiveness of using magnitude as an indicator of tsunami generation can be evaluated as 75% effective. These events were registered in the Kurile-Kamchatka zone and its neighborhood during the period 1962-1980 and were registered by long-period seismographs at teleseismic distances; the earthquakes considered were in the magnitude range from 5.8 to 8.2. A total of nine tsunami-generation indicators were considered. It was found that when magnitude is supplemented by one of the new indicators of earthquake tsunami generation (duration or velocity of propagation of dislocation at the focus, rate of increase in maximum or total duration of long-period P wave) the effectiveness is increased to 90%. In prediction work the most effective approach is a combination of earthquake magnitude, duration and velocity of dislocation propagation (the latter two parameters were determined by the A. V. Vvedenskiy method). The effectiveness of prediction in this case can exceed 90%. This research also confirmed that there is a dependence of earthquake tsunami generation on earthquake focal mechanism. However, this indicator is less effective than the form parameters examined in this article, and in part, the spectrum of the long-period P wave. According to the teaching material, data on the form of the long-period P wave were more informative for predicting tsunamis than data on the wave spectrum, including the ChISS spectrum, although this does not negate the need for further work with ChISS records and refinement of the possibilities of predicting earthquake tsunami generation by use of such records. Taking into account the possibility of increasing the effectiveness of the routine prediction of tsunamis to almost 90% or more, everything possible must be done to develop methods for evaluating indicators of earthquake tsunami generation at teleseismic distances directly on the records of stations in the operational service, that is, at epicentral distances 100-1000 km. Figures 4; tables 10; references 21: 16 Russian, 5 Western.
[8-5303]

PHYSICS OF ATMOSPHERE

BRIEFS

TEMPERATURE CHANGES IN STRATOSPHERE--Sharp and sudden temperature fluctuations in the stratosphere over the Earth's polar regions have been recorded by Soviet scientists. According to data from radio sounding, the temperature over the Arctic and Antarctic at an altitude of 50 kilometers can increase 40°C in several hours. The centers of such "explosions" form, as a rule, over geomagnetic areas and then migrate over enormous distances independently of the meteorological conditions. Researchers from the Arctic and Antarctic Scientific Research Institute attribute the mechanism for this phenomenon to the interaction of corpuscular radiation from the sun with the Earth's magnetic field at the border of outer space. The answer to the "heat explosions" put forth by Leningrad aerologists is interesting not only for scientific reasons, but for practical reasons as well. Such phenomena are reliable precursors of magnetic storms. [Text] [Kishinev SOVETSKAYA MOLDAVIYA in Russian 16 Sep 81 p 2]

CSO: 1865/9-P

STUDY OF OZONE LAYER--The protective shield of our planet, the ozone layer, turned out to be inert to the solar eclipse which occurred 31 July of this year. Results of observations made by scientists of the Institute of Physics of the Atmosphere of the USSR Academy of Sciences from a plane-laboratory in east Siberia pointed to this characteristic of ozone, which was unknown until now. A change in the intensity of solar radiation during an eclipse, as expected, should have affected the concentration of ozone; and this in its turn would cause short-period disturbances in the weather. However, as observations from the plane showed, the ozone did not react to the passing of the moon's shadow. At the same time, other mixtures, like oxide and nitrogen dioxide, turned out to be very sensitive to the eclipse. Just as the shadow of the moon covered the surface of the earth, their concentration was reduced by 50 percent. The next stage of work for scientists of the Institute of Physics of the Atmosphere is to explain this incomprehensible behavior of ozone. Without this, it would be impossible to compose mathematical models of the photochemical processes in the atmosphere, prognosis of pollution in the stratosphere, and future change in the climate. [Excerpt] [Riga SOVETSKAYA LATVIYA in Russian 31 Oct 81 p 2]

CSO: 1865/34-P

MODELS OF OPTICAL CHARACTERISTICS OF ATMOSPHERIC AEROSOL OVER CONTINENTS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 260, No 1, Sep-Oct 81
(manuscript received 17 Mar 81) pp 56-59

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[Abstract] Over the continents the optical characteristics of atmospheric aerosol are formed by the finely disperse fraction of background aerosol, the fraction of soluble substances, the submicron and coarsely disperse fractions of dust aerosol. Figure 1 in the text gives an example of a microphysical model of atmospheric aerosol over a subarid region in the zone of active turbulent exchange. The fraction of soluble substances is the most stable and its vertical profile varies slightly with time of day and season. The nuclear mode is a result of atmospheric photochemical transformations in the gaseous phase. The microstructure and optical properties of the dust aerosol are determined by the state of the underlying surface and the degree of atmospheric turbulence in the zone of active turbulent exchange. With an atmospheric relative humidity $< 75\%$ its influence on the optical characteristics of aerosol can be neglected. Under stable weather conditions the submicron and coarsely disperse fractions of dust aerosol exert a decisive influence on the optical characteristics. The most coarsely disperse aerosol fractions appear important during dust storms. The vertical structure of the concentration of dust aerosol is essentially dependent on micro- and macroscale atmospheric circulation. For conditions of absence of a dust storm the mean concentration of dust aerosol over arid and subarid zones is approximately constant with an optical density $\partial\tau_a/\partial Z = 0.05-0.07 \text{ km}^{-1}$ with an altitude of the zone of active turbulent exchange of 3-4 km. Under storm conditions the altitude of dust transport and the optical density $\partial\tau_a/\partial Z$ are dependent on the degree of development and the character of the dust storm. Dust storms arising during the passage of a cold front are characterized by a number of stages in their development. In the initial stage in the region of the storm focus the dust rises into the above-lying layers of the atmosphere due to powerful vertical air currents in the region of the storm front. In this development stage the vertical profile of the concentration of dust particles corresponds more to an exponential

decrease in dust concentration with altitude. With a further development of dust transport the dust concentration in the upper layers of the zone of active turbulent exchange increases. In this dust storm development stage the vertical concentration profile evens out and is slightly dependent on altitude. From the moment of formation of the dust cloud at altitudes 3-5 km the storm front is displaced together with movement of the pressure formation and the dust cloud is entrained into the high-level atmospheric circulation. With continued movement it gradually is impoverished of the fraction of large particles. In this dust transport stage the dust concentration in the lower layers of the atmosphere is less than in the middle layer. A second type of dust storm occurs when there is a meeting of pressure formations of an opposite sign. A figure in the article illustrates a model of the optical characteristics of aerosol over the continents for summer, winter and autumn conditions in the middle latitudes. Figures 3; tables 1; references 8: 5 Russian, 3 Western. [25-5303]

UDC 550.388.2

EXTENT OF SOURCES AND MECHANISMS OF GENERATION OF SPORADIC RADIO EMISSION IN AURORAL IONOSPHERE IN SHF REGION

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 80
(manuscript received 8 Jul 80) pp 738-740

OSIPOV, N. K., KLIMENKO, V. V. and CHERNOV, A. A., Krasnoyarsk State University

[Abstract] The authors estimate the extent and localization of regions of generation of radio emission of the auroral ionosphere. Until now these matters have been investigated only on the basis of indirect data. The experimental method used involved the following. It is known that the equivalent noise temperature of an antenna T_A is dependent on the spatial distribution of brightness temperature T_B of a source and the relationship of the angular dimensions of the radio emission source Ω_S and the angular dimensions of the antenna directional diagram. By changing the width of the antenna directional diagram and controlling the corresponding changes of T_A it is possible to estimate the angular dimensions of the source on the assumption that the brightness temperature and the solid angle of the source remain constant or change with time much more slowly than the changes in the width of the antenna directional diagram. Taking this into account, at Noril'sk station a long series of measurements was made during the period October 1976-March 1977 at a frequency of 2805 MHz (10.7 cm) using two antennas the solid angles of whose directional diagrams were $\Omega_{A1} \approx 10^{-3}$ and $\Omega_{A2} = 1$ sr. The antennas were alternately switched to a radiometer input for prolonged and equal time intervals. There were two types of auroral ionosphere radio emission: bursts and the slowly changing component. It was found that for the slowly changing component the antenna temperature T_A in general is not dependent on what antenna is used for reception, but for emission of the bursts type when making observations with the pencil-beam antenna T_A on the average is three times greater than when making observations

with a wider antenna diagram. It was found that the angular dimensions of the sources of radio emission of the slowly changing component type are greater than the angular dimensions of the directional diagram of the antenna with a wider diagram. For emission of the bursts type there was a commensurability of the angular dimensions of the source and the angular dimensions of the directional diagram of the pencil-beam antenna. A quantitative interpretation of the data was made by computing the antenna temperatures for three probable source configurations: a) point source; b) partial filling of the directional diagram; c) total filling. For the most probable range of altitudes of localization of the source of the slowly changing component $400 > h > 100$ km) the diameter of the cross section of the source of emission of the slowly changing component should be more than 100 km. For emission of the bursts type the filling of the directional diagram of the wider antenna is incomplete and with a constant intensity of the source, localized in this same altitude range, the estimates of dimensions of the sources give values of some tens of kilometers. It appears that emission of the slowly changing component type is of bremsstrahlung origin. Emission of the bursts type may not be of bremsstrahlung origin. Figures 2; references 4: 2 Russian, 2 Western.
[244-5303]

UDC 550.385.3

STRUCTURE OF EARTH'S NATURAL SUPERLOW-FREQUENCY ELECTROMAGNETIC FIELD IN ARCTIC BASIN

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 18 Feb 80) pp 709-714

BOGORODSKIY, V. V., GUSEV, A. V., POLYAKOV, A. P., USPENSKIY, N. I. and YARTSEV, M. B., Arctic and Antarctic Research Institute

[Abstract] The general structure of the natural electromagnetic field in the superlow-frequency range has been studied extensively but there have been no experimental studies of this type for the Arctic basin. The authors felt it important to examine the possible effects associated with the presence of an ice cover. On the "Severnnyy Polyus" drifting station simultaneous observations were made of the components of the electromagnetic field in the range 0.5-100 Hz, natural oscillations of the ice cover and the acoustic emission arising during dynamic effects in the ice cover. The experiments were carried out in the region 80° N in the spring and summer of 1979; during the measurements of the natural electromagnetic fields the degree of geomagnetic disturbance was moderate ($K_p \leq 3$). The instrumentation employed is described. Sensors placed on the ice surface registered the mutually perpendicular horizontal components of the magnetic field H_x and H_y and seismic detectors registered oscillations of the ice cover at the same sites. In the near-ice water layer there were long bases for measuring the horizontal components of the electric field E_x and E_y . Observations were made under both natural conditions and with the excitation of seismoacoustic waves in the ice and water using artificial sources. The results of these experiments indicated that among all the possible sources of the

electromagnetic field in the considered frequency range the principal contribution to the natural electromagnetic field in the Arctic basin is the field of atmospheric sources (excitation of the earth's waveguide - ionosphere), as is confirmed by clear registry of Schumann resonances. Figures 3; references 10: 9 Russian, 1 Western.

[244-5303]

UDC 550.383

CAUSES AND EFFECTS OF NONSTATIONARY POLAR WIND

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 19 Feb 80) pp 698-703

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[Abstract] The supersonic flow of plasma along the lines of force of the geomagnetic field in the polar region (polar wind) is a reflection of macroscale magnetospheric-ionospheric circulations of plasma complicating convective movements and leading together with convective transport to a quite complex picture of magnetospheric-ionospheric interactions and their effects. P. M. Banks, et al. (JGR, Vol 74, No 26, pp 6304, 6317, 1969; PLANET. SPACE SCI., Vol 19, No 9, p 1053, 1971) developed a stationary model of the polar wind consisting of continuity equations and equations of motion for O^+ and H^+ ions which are integrated along the lines of force of the geomagnetic field. A feature of this model was the discrimination of two regions: the region of altitudes where the Mach number $M < 1$ and the region where the Mach number $M > 1$, with an appropriate solution being obtained in each region. Since the spatial position of the critical point of transition of the flow to a supersonic regime was unknown in advance, this position was stipulated in advance as an initial parameter of the problem. Such a stationary model is clearly inadequate for studying the real nature of the polar wind and the authors accordingly have formulated a nonstationary model. In this nonstationary model in the numerical solution the position of the critical point is determined automatically and is dependent on the boundary conditions at the upper boundary. The solution of the nonstationary problem involves solving a full system of gas-dynamical equations in a dipolar coordinate system. Within this one-dimensional system the authors analyze different regimes of escape of ionospheric plasma into the magnetosphere in the polar region. It is demonstrated that the dilution of the tubes of the earth's magnetic field, as a result of low pressure at altitudes of about 1,000 km, results in the supersonic escape of plasma and the concentration of hydrogen and atomic oxygen at altitudes greater than the altitudes of the maximum of the F2 layer concentration is substantially reduced. Figures 6; references 13: 4 Russian, 9 Western.

[244-5303]

MULTIMODE BROADENING OF SHORT-WAVE SIGNALS ALONG EXTENSIVE PATHS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 3 Dec 80) pp 652-660

LOBACHEVSKIY, L. A., NEKRASOV, B. Yu., SMIRNOV, V. B., SUAREZ, H. B.,
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[Abstract] The article gives the results of experimental investigation of multimode broadening of pulsed signals under equinoctial conditions on two extensive paths: Nikolayev-Havana (9,830 km) and Moscow-Molodezhnaya (13,720 km) and also the results of theoretical computations of multimode broadening on the Nikolayev-Havana path. A comparison of the results of both experimental measurements and theoretical computations made it possible to draw some conclusions concerning the effects of multimode broadening, absorption and scattering along these extensive paths. The experiments with slant sounding on the Nikolayev-Havana path were made in 1973-1974. Radiation was at a number of fixed frequencies in the range 7-21 MHz with pulses having a duration $\tau_{\text{rad}} \leq 1$ msec. Measurements were made of the duration τ of the received signals at the 0.5 level of the amplitude maximum. In most cases the duration of the received signals substantially exceeded the duration of the radiated signal. Experiments with slant sounding along the Moscow-Molodezhnaya path have been made regularly since 1973. The Moscow transmitter radiated pulses with a duration of 0.1 msec with a repetition rate of 50 Hz. Slant sounding ionograms were registered at Molodezhnaya each hour. Data were collected on multimode broadening of slant sounding signals obtained from ionograms for the equinoctial periods 1978-1979 (solar activity maximum). The broadening of the pulses along the Nikolayev-Havana path for the most part did not exceed 3 msec. However, at the high frequencies the broadening attained 5-5.5 msec. Along the Moscow-Molodezhnaya path the basic multimode signal broadening is about 1-2 msec, with an extremely rare maximum up to 4 msec. Thus, there is a considerable difference between the two paths. Comparison of the computed and experimental data indicates that the data obtained by the processing of ionograms corresponds better to the computations than do the data from experiments at fixed frequencies. The mechanisms of propagation along these paths are analyzed and the reasons for discrepancies between experimental and computed values are explained. Figures 5; references: 19 Russian.
[244-5303]

ROLE OF VISCOUS INTERACTIONS IN FORMATION OF ELECTRIC CURRENTS IN POLAR IONOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 25 Mar 80) pp 643-646

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[Abstract] In order to clarify the role of the earth's rotation in the generation of electric fields and currents in the magnetospheric region resting on the polar cap the author made a study of plasma over a rotating disk with a magnetic field normal to the surface. The disk rotates with the angular velocity ω and the magnetic field is at the distance H_0 from the disk. The plasma is represented by a homogeneous incompressible fluid with the conductivity σ and the viscosity μ . It is required that the attachment condition is satisfied on the disk itself and with increasing distance from its surface the velocity of rotation attenuates. The model makes it possible to predict the behavior of plasma over the polar caps. The model reveals the following. 1) The earth's rotation brings into rotation the lower part of the plasma columns resting on the polar caps. The region of transition from rest to rotation is quite thin (about 10 km). 2) There is generation of electric currents flowing in a radial direction to the axis of rotation and flowing out along the lines of force of the geomagnetic field. If the plasma of the plasmosphere rotates as a whole together with the earth's atmosphere, electric currents will flow along the plasmopause. They are concentrated in a narrow layer and flow toward the boundary of the rotating disk. With further motion from the plasmopause to the axis of rotation the density of the currents undergoes a linear decrease. 3) Atmospheric rotation in surrounding plasma inevitably leads to convection of its upper layers. The rates of convection can attain tens of $\text{m}\cdot\text{sec}^{-1}$ at altitudes 90-100 km and hundreds of $\text{m}\cdot\text{sec}^{-1}$ at greater altitudes. Convection increases in the nighttime hours and decreases sharply in the daytime hours and in periods of substorms when there is a considerable increase in conductivity. Such convection undoubtedly considerably changes the chemical composition of the atmosphere and regulates the vertical distribution of the density of individual chemical components. 4) The ohmic losses of the generated currents can play an appreciable role in the thermodynamics of the entire atmosphere. The greatest contribution is from f_r and f_y currents in the nighttime hours. At this time the ohmic losses can attain tens of $\text{erg}\cdot\text{sec}^{-1}$ in a column with a section 1 cm^2 and a height z^* , which should lead to heating of the upper atmosphere and appearance of IR radiation. 5) The qualitative pattern of the electric currents generated in the magnetosphere and ionosphere over the polar cap is as represented in Fig. 1 in the text. Figures 1; references: 5 Russian.
[244-5303]

COMPARING CHARACTERISTICS OF IONOSPHERIC INHOMOGENEITIES OF H_E TYPE IN MIDDLE LATITUDES AND E_{sq} TYPE IN POLAR AND EQUATORIAL ZONES

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 27 Feb 80) pp 623-629

FILIPP, N. D., Bel'tsy State Pedagogic Institute

[Abstract] Investigations of characteristics of distant ionospheric propagation of ultrashort radio waves in the middle latitudes enabled the author to draw conclusions concerning the nature of magnetically oriented inhomogeneities responsible for aspect scattering and so-called diffuse H_E inhomogeneities. The experiments for studying the nature of diffuse H_E inhomogeneities were made on a middle-latitude path ($45^\circ N$) with an extent 1,400 km at frequencies 44 and 74 MHz. Quasicontinuous H_E signals are caused by diffuse inhomogeneities of the E region of the E_{sq} type, consisting of small-scale inhomogeneities elongated along the lines of the geomagnetic field and characteristic for the equatorial and polar zones. A study was made of the correlation between sporadic layers with a high electron concentration and quasicontinuous H_E signals, as well as the role of magnetic and ionospheric disturbances in the formation of field-oriented anisotropic inhomogeneities. It was found that: a) the presence of highly ionized E_s layers, and accordingly, the existence of even a highly inhomogeneous ionospheric structure does not cause the scattering of quasicontinuous H_E signals if the difference between the limiting frequency and the screening frequency is insignificant ($\Delta f E_s < 0.5$ MHz); b) there is a good correlation between the transmission of quasicontinuous H_E signals and the existence in the active scattering region of E_s layers with a screening frequency $f_b E_s < 5$ MHz and with a considerable difference between the limiting frequency and the screening frequency of the layer ($\Delta f E_s > 1$ MHz). Even with the existence of only slightly ionized E_s layers, but with considerable $\Delta f E_s$, there is a coincidence between the presence of such a layer and the appearance of H_E scattering; c) there is no correlation between magnetic disturbance and the appearance of H_E signals. The article enumerates a whole series of characteristics of diffuse inhomogeneities of the ionospheric E region in the middle latitudes responsible for the scattering of quasicontinuous H_E signals similar to the corresponding characteristics of diffuse E_{sq} layers in the equatorial and auroral zones and on this basis it can be assumed that their nature for the most part is one and the same. It is demonstrated that the presence of highly ionized E_s layers is not an adequate condition for aspect scattering of ultrashort-wave signals. It is slightly ionized E_s layers with a considerable difference between the $f_o E_s$ and $f_b E_s$ frequencies which are responsible for this phenomenon. Figures 4; references 19: 16 Russian, 3 Western.
[244-5303]

INVESTIGATING ROLE OF DIFFERENT MECHANISMS IN FORMATION OF IONOSPHERIC F2 REGION IN TWO-DIMENSIONAL MODEL

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 11 Feb 80) pp 612-616

KOLESNIK, A. G. and GOLIKOV, I. A., Siberian Physical-Technological Institute and Yakutsk State University

[Abstract] The objective of this study, made within the framework of the two-dimensional nonstationary model of the F region developed earlier by the authors (GEOMAGNETIZM I AERONOMIYA, Vol 21, No 1, 1981), was an investigation of the role of electric fields of magnetospheric origin, thermospheric winds, flows of thermal plasma at the upper boundary and ionization of neutral components by streams of auroral particles in the electron concentration distribution. It was found that with respect to the relative effectiveness of the investigated mechanisms of distribution of electron concentration in the F2 region the northern hemisphere is conveniently divided into three latitude zones. The first zone with $\theta \leq 25^\circ$ relates to the high-latitude ionosphere. In this zone the distribution of electron concentration is controlled primarily by plasma convection due to electric fields of magnetospheric origin and auroral ionization due to leaking electrons. These mechanisms can change n_{\max} by an order of magnitude and h_{\max} F2 as much as 80 km. In this zone the other mechanisms play a secondary role and can change n_{\max} F2 by a factor of about 2 and h_{\max} F2 by as much as 30 km. The second zone with $25^\circ \leq \theta \leq 35^\circ$ is a transition region between the high- and middle-latitude ionosphere. It is characterized by effectiveness of all the investigated mechanisms forming the distribution of the electron concentration. Each mechanism separately can change n_{\max} F2 by about an order of magnitude and h_{\max} F2 by up to about 50 km. The third zone with $35^\circ \leq \theta \leq 70^\circ$ relates to the middle-latitude ionosphere. In this zone the meridional transport of plasma and the role of auroral ionization are negligible, which validates the applicability of a one-dimensional approximation in solution of the continuity equation for the charged component in a diffusion formulation. The boundaries of the defined latitude zones are arbitrary and are controlled by the time of day. Figures 4; references 18: 13 Russian, 5 Western.
[244-5303]

PARAMETRIC DECAY OF VERY POWERFUL HIGH-FREQUENCY RADIO WAVES IN IONOSPHERIC PLASMA

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 4, Jul-Aug 81
(manuscript received 18 Aug 78, after revision 22 Jul 80) pp 602-606

ABYZOV, A. S., BAKAY, A. S. and SOLODOVNIKOV, G. K.

[Abstract] Many studies have been devoted to artificial modification of the ionosphere by powerful radio radiation. However, for the most part ionospheric modification by radio waves in the short-wave range has been considered. Therefore, the authors investigated such modification by a high-frequency radio wave. In this case with a transmitter power exceeding some threshold instabilities develop in ionospheric plasma which are associated with the nonlinear interaction between the radio wave and the plasma. These instabilities can lead to an anomalously great attenuation of the radio wave. Allowance need be made for only three types of waves: transverse electromagnetic, longitudinal Langmuir and ionosonic waves. With allowance for ionospheric conditions a study was made of the processes of decay of a high-frequency radio wave into Langmuir and transverse electromagnetic waves and into ionosonic and electromagnetic waves. The decay occurs in the following way. The initial electromagnetic wave is scattered on longitudinal waves and imparts some of its energy to them, which leads to a growth of the latter. With an increase in the amplitude of the longitudinal waves there is an increase in the fraction of energy removed from the initial radio wave and therefore the process has the form of a plasma instability relative to the buildup of longitudinal waves in the field of the strong electromagnetic wave and can lead to a considerable decrease in the amplitude of the initial wave. With these factors taken into account, the authors examine the parametric instability of ionospheric plasma in the field of a powerful radio wave in the meter range. Computations are made for the threshold fields and increments of increase of perturbations in the case of a radio wave radiated by a ground source for specific states of the ionosphere. Figures 3; references 15: 9 Russian, 6 Western.
[244-5303]

VARIABILITY OF REFRACTIVE INDICES OF RADIO AND ACOUSTIC WAVES ACCOMPANYING HUMIDITY AND TEMPERATURE VARIATIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 17, No 8, Aug 81 (manuscript received 6 May 80) pp 869-872

KOPROV, B. M., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] Due to the smallness of variations of temperature and humidity it is possible to consider them to be related by a linear dependence to fluctuations of air density and the refractive index of acoustic waves and radio waves. With this taken into account, it is easy to establish the relationship between the statistical characteristics of the enumerated parameters and the characteristics of temperature and humidity variations. The purpose of this study was a comparison, on the basis of experimental data, of the relative contribution of temperature and humidity variations to variations of air density and the refractive indices of radio and acoustic waves with some typical conditions for the near-surface and near-water layers. It is shown that in the near-surface layer of the atmosphere, both in summer in the daytime and in winter the variations in density and the refractive index of acoustic waves are determined almost exclusively by temperature variations. It is also possible to neglect the influence of humidity fluctuations on the refraction of acoustic waves. However, the influence of humidity fluctuations on the refraction of radio waves is not negligible even under these conditions. In the near-water layer of the tropical ocean, on the other hand, the contribution of humidity fluctuations to density fluctuations and the coefficient of refraction of acoustic waves and radio waves is extremely significant. For radio waves this contribution is ten times greater than the contribution of temperature fluctuations. This means that under these conditions a refractometer can serve as a humidity sensor. With respect to the contribution of humidity fluctuations to the buoyancy force, it is approximately equal to the temperature contribution. It follows that under these conditions it is impossible to measure temperature with an acoustic thermometer without allowance for the influence of humidity. However, an acoustic refractometer can be used for measuring humidity under the condition of correct exclusion of the influence of temperature on its readings. For this purpose it is possible in principle to employ the quite widely used acoustic anemometer, but it is necessary to measure not the phase difference of the signals received by two microphones situated at equal distances from a source, but their sum; the temperature fluctuations in this case must be measured independently. Tables 1; references 14: 6 Russian, 8 Western.
[1-5303]

FREQUENCY SPECTRUM OF SCATTERED SIGNAL IN ATMOSPHERIC RADIOACOUSTIC SOUNDING SYSTEMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian, Vol 17, No 8, Aug 81 (manuscript received 3 Jun 80) pp 883-886

AZIZYAN, G. B., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] One of the principal problems in radioacoustic sounding systems is assurance of the necessary decoupling between the transmitting and receiving antennas. The difficulties associated with this are caused by the low power of the scattered signal and these cannot always be overcome in continuous sounding systems. This dictates the use of pulsed sounding systems, those in which the radio transmitter operates in a regime of radiation of short powerful pulses. With a sufficiently short length of the radio pulse the processes of radiation and reception of a radio signal are separated in time, making possible solution of the problem of antenna decoupling, that is, a virtually ideal decoupling with some limitations on the minimum sounding altitude. This necessitates computing the spectrum for the scattered signal, since data in the literature do not make it possible to answer all the questions relating to the method for processing the scattered signal. In this article the author derives an expression which makes it possible to compute the spectrum of the scattered signal with extremely general assumptions concerning the shape of the acoustic and electromagnetic pulses. When the sounding is with a series of electromagnetic pulses the spectrum of scattered radiation is displaced relative to the spectrum of the transmitted radiation by the Doppler frequency. This makes it possible to use an ordinary Doppler radar with range selection in a radioacoustic sounding system. With a length of the electromagnetic pulse ≤ 100 m the radiation and reception will be separated in time, that is, there will be an ideal decoupling between the receiving and transmitting antennas. References: 4 Russian. [1-5303]

UDC 550.386

POSSIBILITY OF PREDICTING GEOPHYSICAL ACTIVITY FROM INTERPLANETARY SCINTILLATIONS OF RADIO SOURCES

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 3, May-Jun 81 (manuscript received 14 Jan 80) pp 441-444

VLASOV, V. I., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Prolonged (63 days) observations of interplanetary scintillations were made during the period August-October 1976. Each day observations were made of the scintillation of about 150 radio sources. The principal purpose of these observations was the mapping of interplanetary inhomogeneous plasma within distances of 0.2-1.5 a.u. from the sun at all heliocentric latitudes.

These maps clearly show the macroscale structure and dynamics of interplanetary plasma, but it is more convenient to use curves of change in the scintillation indices $m_1(t)$ for all the observed sources. The analysis of this family of curves revealed a marked increase in the scintillation indices for many radio sources on individual days. A comparison of the $m_1(t)$ curves with the curve of changes in the planetary geomagnetic index A_p indicated that some cases of intensification of the scintillation indices are accompanied by an increase in the A_p index. A correlation analysis of the $m_1(t)$ and $A_p(t)$ curves was also made. It was found that the indices of scintillations of most of the observed radio sources correlate poorly with $A_p(t)$ and only for some sources did the maximum correlation coefficient attain $\sim 0.3-0.4$. The analysis of these and other data indicates that there is a direct dependence between the state of interplanetary plasma and geomagnetic activity. There is a distinct lag between variations of the geomagnetic index and the index of interplanetary scintillations. Accordingly, it is possible to predict geophysical activity on the basis of radioastronomical observations of interplanetary scintillations of radio sources. Figures 3; references 4: 3 Russian, 1 Western. [26-5303]

UDC 550.388.2

EXPERIMENTAL INVESTIGATION OF EFFECTS OF SELF-INFLUENCE OF POWERFUL RADIO WAVES AT ELECTRON GYROFREQUENCY IN IONOSPHERIC F REGION BY DOPPLER METHOD

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 3, May-Jun 81
(manuscript received 24 Jul 80) pp 445-450

VAS'KOV, V. V., VYAZNIKOV, V. V., GOLYAN, S. F., GRUZDEV, Yu. V., GUREVICH, A. V., KIM, V. Yu., LOBACHEVSKIY, L. A., MIGULIN, V. V., PANCHENKO, V. A., PETROV, M. S., POLIMATIDI, V. P., SERGEYENKO, O. S., SITNIKOV, V. I., KHAR'KOV, I. P., SHLYUGER, I. S. and YURIN, K. I., Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences, and State Scientific Research Radio Institute

[Abstract] The authors investigated the modification of the upper layers of the ionosphere by powerful radio waves. A system for Doppler sounding of the ionosphere by powerful pulsed radio radiation at frequencies close to the gyrofrequency of electrons $f_H = 1.35$ MHz was developed and constructed. This made it possible to determine the spectral characteristics of radio signals with a high resolution. The Doppler investigations made in 1979 are presented here. In investigating the effects of nonlinear self-influence of powerful radio waves it is necessary to vary the power in a quite broad range. The radiated power was varied by a factor of 10, which guaranteed absence of a significant self-influence despite a small power level. The pulsed nature of the radiation (pulse duration $\tau = 500$ μ sec, repetition rate 50 Hz) made it possible to investigate the effects of self-influence when there is a small spatial separation of the transmitter and receiver. The experiments were made at nighttime (2300-0400 hours Moscow time) when the radiated wave was reflected

at the altitudes of the F-layer in the ionosphere. The reception point was located about 18 km to the south of the transmitter so that the radio signal trajectory was almost vertical. There was found to be two effects of self-influence of powerful radio waves in the F layer: 1) anomalous attenuation of a powerful radio wave reflected from the ionosphere, 2) broadening of the Doppler spectrum of the radio signal in the region of lower frequencies. The first of these effects is attributable to the excitation of striction parametric instability in the region of reflection of the powerful radio wave. The second observed effect, the asymmetric broadening of the Doppler spectrum of the radio signal carrier frequency for the most part in the region of negative frequencies, attaining 6-7 Hz, is evidence of the excitation of artificial inhomogeneities moving upward and downward relative to the level of reflection of a powerful radio wave. The velocity of movement of artificial inhomogeneities relative to the reflection level is estimated at ± 400 m/sec, which is close to the thermal velocity of ions in the upper layers of the ionosphere. There was a difference in the degree of manifestation of these effects during different seasons of the year which is related to the difference in ionospheric parameters in April and December. In the first case the reflection of the radio wave occurred at a lesser altitude and with a greater electron concentration gradient than during winter. This is consistent with the theoretical finding that there is an intensification of the self-influence of radio waves in a plasma layer with a lesser electron concentration gradient. Figures 4; references 8: 7 Russian, 1 Western.
[26-5303]

UDC 550.388.2

PROSPECTS FOR MODELING INHOMOGENEOUS STRUCTURE OF IONOSPHERE AND PREDICTION OF IONOSPHERIC SCINTILLATIONS OF RADIO SIGNALS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 3, May-Jun 81
(manuscript received 16 Nov 79) pp 466-471

ALIMOV, V. A. and RAKHLIN, A. V., Gor'kiy Radiophysics Institute

[Abstract] The problems involved in the modeling of the inhomogeneous structure of ionospheric plasma were examined by E. J. Fremouw, et al., RADIO SCI., Vol 8, No 3, 1973, and J. H. Pope, RADIO SCI., Vol 9, No 7, 1974. In those articles, by means of a comparison of the results of different experimental investigations of the amplitude scintillations of discrete radio sources and artificial earth satellites and the corresponding results of computations of the indices of scintillations, the authors formulated a globally averaged model of inhomogeneities of electron concentration in the ionospheric F layer. However, in the opinion of the authors of this article, both the models in RADIO SCIENCE have serious shortcomings. The most important of these are: use in the theoretical computations of an approximation of weak disturbances and approximation of the spectrum of inhomogeneities of ionospheric electron concentration by a Gaussian function; use of different averaged morphological amplitude

indices of signal scintillations $S_{1,2,3,4}$ as initial data for constructing the model and incompleteness of information on their dependence on geophysical conditions. All these shortcomings substantially reduce the effectiveness of the Fremouw and Pope models both for geophysical investigations and for solution of practical problems (such as prediction of the noise immunity of space radio communications). This article gives a resolution of these difficulties. The general principles for formulating such a model are outlined and it is discussed in relation to radio forecasts, particularly prediction of the noise immunity of a single-channel telegraphic communication line. Figures 1; references 12: 4 Russian, 8 Western.
[26-5303]

UDC 550.388.2

CHARACTERISTICS OF ENVELOPE OF BACKSCATTER SOUNDING SIGNALS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 21, No 3, May-Jun 81
(manuscript received 16 Jun 80) pp 558-561

TSIBUL'SKIY, V. R. and KITAYEV, V. V., Tyumen' Industrial Institute

[Abstract] In studying the channels for propagation of backscatter sounding signals it is useful to use a phenomenological approach based on ray representations with ray reflection from a corresponding area of the ionosphere and/or the earth's surface. With more than one reflection there is multiple scattering. In the case of a single reflection or with correctness of the first Born approximation it is assumed that simple scattering occurs. Depending on whether there is multiple or single scattering it is possible to distinguish series-parallel or parallel channel models. It has been concluded that a series-parallel model should be adopted for backscatter sounding signals, in most cases characterized by a log-normal distribution law for the distribution of signal amplitudes. The purpose of this article is to demonstrate the correctness of such a conclusion and to analyze the dependence of the spectral density of fluctuations of the envelope of backscatter sounding signals on the nature of the scattering surface and the distance (R) to it. The conclusions are based on data from 30 sounding sessions. It was found that the most acceptable model of the channel is the series-parallel model, as postulated, that with a change in R the change in the distribution parameter σ relative to m is insignificant and there is a somewhat stronger fluctuation of the envelope of signals reflected from the sea surface in comparison with the case of reflection from the land. The energy spectra of fluctuations of the signal envelope are different in form for different R and different scattering surfaces. The fraction of energy of the high-frequency components of the spectrum increases with an increase in R and is of great importance for all R in the case of reflection from the sea surface in comparison with the case of reflection from the land, which may be related to the Doppler frequency shifts of signals. The presence of a correlation between R and the spectra of signal fluctuations indicates that it is feasible to use spectral characteristics as informative parameters. Figures 2; references 12: 11 Russian, 1 Western.
[26-5303]

DETERMINATION OF RAY TRAJECTORIES IN ATMOSPHERE FOR COMPUTING CORRECTIONS IN PULSED-LIGHT RANGEFINDER MEASUREMENTS

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 9, Sep 81 pp 22-23

ANDRUSENKO, A. M. and PROKOPOV, A. V.

[Abstract] One of the most important factors determining the accuracy in measuring great distances by pulsed-light rangefinders is in the influence of the earth's atmosphere on light propagation. In particular, the curvature of light ray paths as a result of atmospheric inhomogeneity is of considerable importance. In order to take the curvature of these paths into account it is necessary to introduce corrections into the measured values. Their computation is usually based on the replacement of the true path trajectory by the arc of a circle. This replacement is of an approximate character and cannot be recommended as a universal approach ensuring an increase in measurement accuracy. The authors therefore propose that the ray trajectories in the atmosphere be determined from the rigorous equations of light propagation. On the basis of the results obtained by Yu. A. Kravtsov and Z. I. Feyzulín in *RADIOTEKHNIKA I ELEKTRONIKA*, Vol 16, No 10, 1971, a study is made of the general case of an arbitrary dependence of the refractive index on coordinates. A solution is given for the problem of determining the trajectory $y(x)$ of a light ray in a two-dimensionally inhomogeneous atmosphere with the refractive index $n(x, y)$. The proposed method is illustrated in a specific example. (The ray trajectory is determined for an arbitrary model of the atmosphere with a linear change in the refractive index frequently used in the literature). The considered method can be used for integration of the ray equation and computation of the corrections necessary for applications in all cases when the dependence of the refractive index on coordinates is known. References: 8 Russian.

[21-5303]

ARCTIC AND ANTARCTIC RESEARCH

'MIKHAIL SOMOV' DEPARTS FOR ANTARCTICA

Leningrad LENINGRADSKAYA PRAVDA in Russian 8 Sep 81 p 4

[Article by A. Kozlovskiy: "Experiment 'Polyn'ya'"]

[Text] Yesterday the scientific research ship "Mikhail Somonov" departed from Leningrad for the shores of the sixth continent. This is the first ship in the flotilla of the 27th Soviet Antarctic Expedition.

The 11th voyage of the flagship of the Antarctic fleet will last about nine months. This time, in addition to the fact that the ship will participate in supplying all that is necessary for the polar specialists at Soviet Antarctic stations, the scientific personnel aboard it, in collaboration with American scientists, will carry out a great volume of investigations within the framework of the "Polyn'ya" experiment.

Its objectives are described by its director, Candidate of Geographical Sciences E. I. Sarukhanyan, senior scientific specialist of the Arctic and Antarctic Scientific Research Institute:

"The experiment which is to be carried out in the Weddell Sea has been assigned the name 'Polyn'ya.' The 'Mikhail Somov' must overcome hundreds of miles of continuous ice in the eastern part of the sea and enter a polynya which is preserved here even in the winter. The objective of the expedition is a comprehension of the reasons for formation of an expanse of open water amidst the heavy ice, processes of interaction between the ocean and the atmosphere and also in the depths of oceanic waters.

The hydrobiological investigations which will be carried out in this region of the world ocean and at this season of the year for the first time are of extreme interest. Scientists intend to study the biological activity of living organisms living in Antarctica in order to clarify some peculiarities of adaptation to extremal conditions. This problem will be investigated by researchers from the All-Union Scientific Research Institute of Fishing and Oceanography and their colleagues from the United States.

The formation of synoptic eddies and vertical currents both in the atmosphere and in the ocean and the clarification of the mechanism of formation of cold bottom waters will become the subject of study by meteorologists, aerologists and oceanologists.

Now three new scientific laboratories have been outfitted on shipboard: hydrological, hydrochemical and hydrobiological. These are outfitted with the latest Soviet and American instruments.

Thirteen American scientists, under the direction of Professor Arnold Gordon, will participate in all aspects of the scientific program and will board the 'Mikhail Somov' at Helsinki and Montevideo."

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EARLY START FOR 27TH SOVIET ANTARCTIC EXPEDITION

Moscow VODNYI TRANSPORT in Russian 3 Oct 81 p 4

[Article by G. Bregman: "Toward Antarctica"]

[Text] In contrast to the established traditional times, no Soviet Antarctic Expedition has begun as early as the 27th. Its flagship, the "Mikhail Somov," is already proceeding with the advance party of polar specialists from the Baltic to the Antarctic Ocean. Five other ships are being prepared for departure to that destination.

The head of this expedition, Candidate of Technical Sciences D. Maksutov, recipient of the Order of the October Revolution and the Order of the Red Star, in an interview with a VODNYI TRANSPORT correspondent, stated: "With respect to the planned scientific and transport operations, the number of participants and technical outfitting, the new expedition, carried out by the Arctic and Antarctic Scientific Research Institute in the Far South, is one of the largest. Year-round and seasonal investigations will be carried out on the sixth continent and in the seas washing it in accordance with national and international programs."

"The scientific ship 'Professor Zubov,' the ice-class freighters 'Vasiliy Fedoseyev' and 'Pioner Estonii,' the passenger liners 'Bashkiriya' and 'Estoniya' are departing from Leningrad, Odessa and Riga. An Il-18D aircraft is making flights along the air route laid out earlier by Aeroflot fliers between Moscow, Leningrad and the main Soviet Antarctic center Molodezhnaya."

"A total of 1,200 scientists, seamen, aviators, mechanics, drivers and other specialists are being sent this great distance. They represent a number of institutes and organizations of the State Committee on Hydrometeorology and Environmental Monitoring and the USSR Academy of Sciences, Ministries of the Navy, Geology and Civil Aviation, and Main Administration of Geodesy and Cartography. Our polar workers will be accompanied by foreign colleagues who will participate in the joint observations. Almost 10,000 tons of equipment and gear, containers with instruments, aircraft, helicopters and powerful tractors capable of cross-country movement will be transported here."

"More than 300 persons will arrive at seven permanent scientific stations located in different regions of the white continent to take up their long watch. They will be headed by the director of the wintering party, Candidate of Physical and Mathematical Sciences R. Galkin, who won his spurs in the Arctic and Antarctica."

"The remaining personnel of the 27th expedition will carry out various kinds of seasonal work. Aboard the 'Mikhail Somov' Soviet and American oceanologists are carrying out a major in situ experiment called 'Polyn'ya' in the inaccessible icy Weddell Sea. The participants of the 10th Antarctic voyage of the 'Professor Zubov' are engaged under the 'Poleks-Yug' program in multisided investigations in the area of the Scotia Sea. About 200 scientists and aviators will be landed from the diesel-electric 'Vasiliy Fedoseyev' and the steamer 'Pioner Estonii' at the seasonal base Druzhnaya and its field camps. Geological-geophysical and cartographic-geodetic study of the ice shelves and mountain ranges adjacent to the shores of the Weddell Sea is being renewed for the seventh time.

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CSO: 1865/20

BRIEFS

PREPARATIONS IN ANTARCTICA--The first tracks of a sled-caterpillar train were imprinted on the ice cover of Antarctica that was sparkling under the spring sun. The director of the "Mirnyy" Observatory, N. K. Dmitriyev, reported yesterday that the trial run of heavy tractors with trailers was successfully completed along the route "Mirnyy"--100km--"Mirnyy". At the finish line, sleds with fuel supplies were left for the upcoming inter-continental trip to the "Vostok" Observatory. The train of 17 tractors will have to deliver to the belt of cold, some 1500 km from shore, the necessary supplies and drilling rigs to continue the core-drilling through the white cap. The upcoming trip will make possible a series of scientific journeys into the inner regions of the sixth continent which are planned for the upcoming research season. Geophysicists, glaciologists, and radio physicists will be dispatched along the distant routes on the sled tractor trains. One of the routes, in particular, will run to the so-called "Kupol-Ts" in the region of the geomagnetic pole. [Text] [Leningrad LENINGRADSKAYA PRAVDA in Russian 9 Oct 81 p 1]

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